ENGINEERING

O GAN
MAY 6 1953
ENGINEERING LIBRARY

this issue

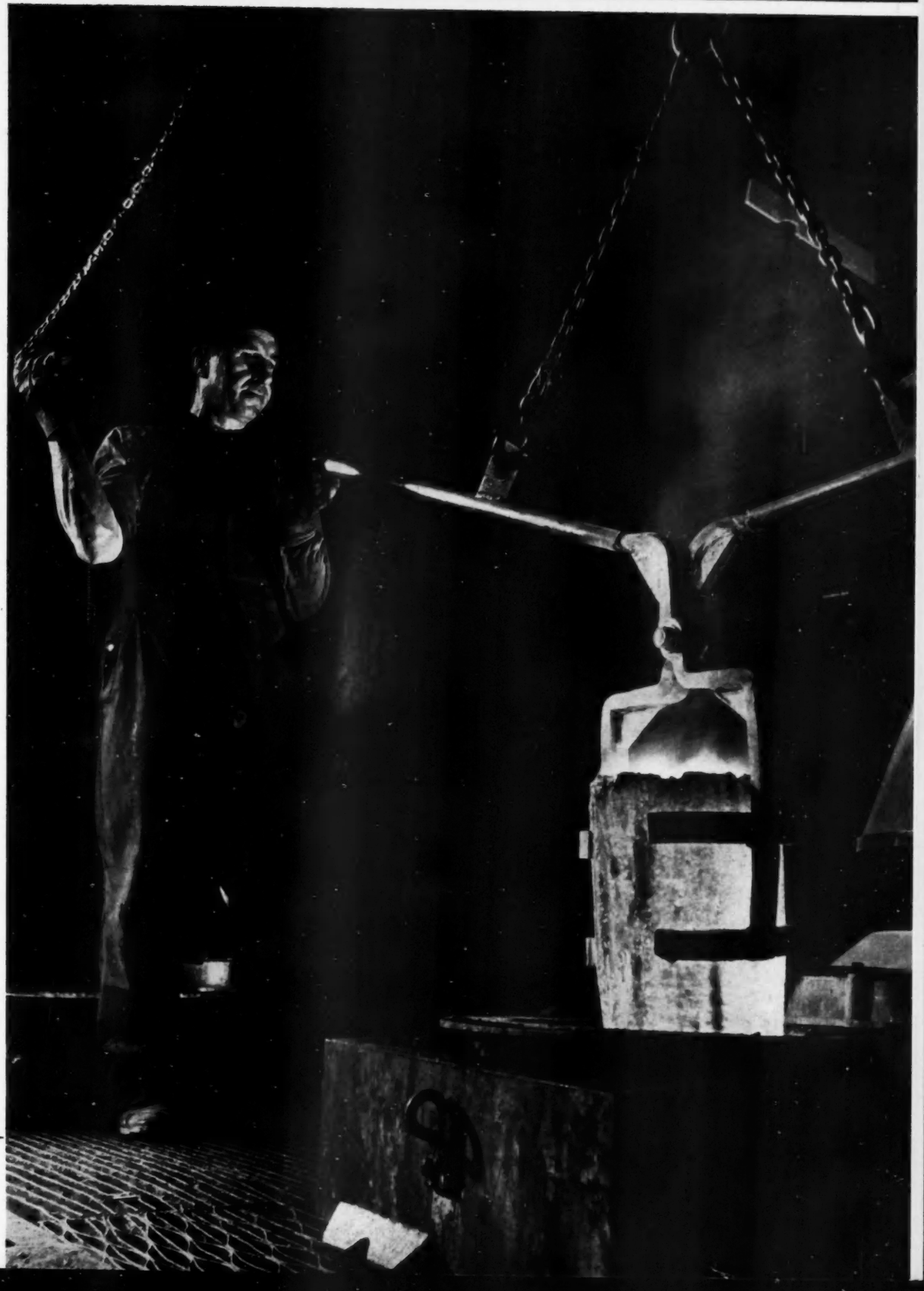
NUCLEAR POWER:
LAKE-SIDE
THE WELSH HILLS

LOYD'S SURVEY
BRITTLE FRACTURE

ABORATORY
OR STUDYING
DANGEROUS MATERIAL

RACTICAL TRAINING FOR
ECHANICAL ENGINEERS

PRICE
2/-



-out Furnace

DUST FUMES and VAPOURS

MUST BE EXHAUSTED

. . . this means loss of space heat and a deterioration of working conditions or process or product

. . . A STURTEVANT

PLENUM HEATING PLANT

will replace these losses and restore conditions.

By consulting STURTEVANT the best of all forms of exhaust and heating plant can be obtained to provide optimum conditions.

Full particulars of Exhaust Ventilation and Plenum Heating may be obtained by writing to our reference D/101/PH.

STURTEVANT ENGINEERING CO. LTD.
Southern House, Cannon Street, London, E.C.4

AUSTRALIA

STURTEVANT ENGINEERING CO. (AUSTRALASIA) LTD. 400, SUSSEX STREET, SYDNEY, N.S.W.

ENGINEERING
PUBLISHED EVERY FRIDAY
Vol. 185 No. 4806 18 April 1958

Contents

481 **Leading Article**
A.M.I.Mech.E.

482 **Plain Words**

483 **Letters to the Editor**
Coriolis Acceleration
Undergraduate Training in Nuclear Power
Anode and Positive are Not Synonymous

489 **Automobile Engineering**
Rolls-Royce Air Conditioning System

490 **Special Article**
For Nuclear Power: A Lake-Side in the Welsh Hills

494 **Atomic Review**
The Material Question

496 **Companies in the News**

496 **In Parliament**

502 **Book Reviews**
The Channel Tunnel
Pressure Measurements in Vacuum Systems

503 **New Books and Trade Publications**

503 **On the Shelf**

511 **Notices of Meetings**

512 **Engineering at Home**
Recording Television Pictures Magnetically
Housing in Timber
Outdoor Lighting

. . . . . .

482 **Management**
Weekly Survey

484 **Plant and Equipment**
Economical Beam Testing Machine
Fireproof Flexible Metallic Hose
Straightening and Cutting Coiled Rod
Air Vice
Ultrasonic Cleaning Plant
Marine Radar
Multi-Channel Oscillograph
For the Factory (Factory Equipment Exhibition)
British Stands at Brussels
Instrumentation and Control on Show

492 **The Human Element**
Practical Training for Mechanical Engineers

497 **Research and Development**
Lloyd's Survey of Brittle Fracture
Laboratory for Studying a Dangerous Material
Measuring Pump Efficiencies by Thermometry

504 **Design**
Hydraulic System Simplifies Crane Control
Spectrograph with Three Measuring Heads

505 **Production**
Welding, Flame Cutting and Fabrication
Food for the Soil: Factory for Concentrated Complete Fertiliser
Colliery Plant for Coke and Chemicals
Indian Blast Furnaces

A.M.I.Mech.E.

THE Council of the Institution of Mechanical Engineers have re-affirmed the principle that a chartered mechanical engineer should have had practical training as well as academic education. This re-affirmation is directed mainly at research engineers, some of whom believe that as engineering becomes more scientific there is a case for allowing some of their number to dispense with practical training in the shops. A research engineer to-day is often nearer to being a scientist than an engineer. His most creative work is likely to be done while he is still comparatively young, and as he has to work through a crowded university syllabus before he can even begin his apprenticeship to research, he may begrudge the year or two spent in the workshops. The Institution's Council are quite firm, however: the aspiring chartered mechanical engineer must have practical training.

To be precise, the Council have not yet set their final seal on this statement of policy. What they have done is to publish a *Report on Practical Training* which has been prepared by a committee appointed by the Council. The report is summarised elsewhere in this issue, and as the President, Sir George Nelson, explains, the Council hope that many comments will be made on it so that, in due course, the Institution's final policy can be published. But although the report is provisional, no one seriously doubts that its main recommendations will be approved.

It is a sensible policy. Engineering is a practical art, and the man who is at the research end of the spectrum should be made aware of this fact through his own practical experience, otherwise he will not talk the same language as the man at the drawing board or the man in the production department. The chairman of the committee, Mr. H. G. Conway, and his twenty colleagues had the task of producing a report which would specify the nature and duration of practical training to be expected of those who take a full-time academic course in mechanical engineering. (A further report for those who do their studies part-time will be prepared later.) The existing examination rules are not very helpful; they refer only to "a period of not less than eighteen months in mechanical engineering workshops in industry." This vague specification gives little guidance to the membership committee, who have to consider applications for corporate membership, or to the school-leaver who wishes to enter the profession.

The report condemns the traditional method of training in which the apprentice spends several years in the production shops, often as a passive onlooker who is given unenlightening repetition tasks but no expert instruction on the theory behind machining and other processes. It recommends the wider adoption of separate training shops, where the apprentice can "learn by doing." This period of Basic Training would be followed by a period of Secondary Training during which the apprentice would rub shoulders with the men on the shop floor. The danger of separate training shops is that a boy's character and independence may not develop so fully as in the old rough-and-ready apprenticeship, when the boy, if he had any guts, would use his own initiative. There is, however, a method of providing both the practical data and the spirit of inquiry, and we suggest that the committee would find it worth investigating. The method is to supply each trainee with a manual which is a guide to the practical knowledge and experience which he should acquire; the manual does not contain the information, it only tells the trainee how or where he can acquire it. This method has proved very successful in one of the process industries; it saves valuable training time without spoon-feeding the apprentice. It would serve as a stimulating catalyst during Secondary Training.

On the controversial question of encouraging apprentices to specialise towards the end of apprenticeship, the requirements for future research engineers are not clear. The report states that "all apprentices, except those definitely destined for a career in research, should spend at least six months on the factory floor." Surely, if the young engineer of high academic attainments is to be allowed a reduced length of practical training, it is important to see that what little time he has is spent in the shops rather than in the clinical atmosphere of a training school? Secondly, what precisely is the value of four weeks in the product design office and four weeks in the jig and tool design office, compared with about fifteen months on production processes? Is a knowledge of design methods, where theory and practice meet, so unimportant to the engineer who may spend the rest of his professional life in manufacture, research or commercial departments?

The Conway Committee have rendered a valuable service to mechanical engineering. As it stands, the report is a series of recommendations; it would have great power if the Council were to place the onus on corporate members of the Institution to see that the recommendations are put into effect.

Cover Picture. *An arrangement of tongs and an air hoist is shown in use for lifting out a crucible of molten metal from a furnace. The hoist is controlled by the chain in the furnaceman's right hand.* (*Nurnberg photograph for* ENGINEERING.)

* * *

Plain Words

A few weeks ago I awarded top marks to the modern lift (alias elevator) for its smooth efficiency as a box for conveying Man from A to B. The equivalent prize-winner among the machines for conveying Man's thoughts is the modern telephone. In Britain it reached a new peak of efficiency recently when the Post Office extended the dialling system over wide areas of the country and made telephoning cheaper than that complex process, dictating/shorthand-writing/typing/checking/signing—so slow in feedback but sure in come-back. (For short distances, incidentally, the telephone is neither as cheap nor as trouble-free as the speaking tube, as the Royal Navy has the sense to remember.)

But it's got me worried. I am worried by the thought of thousands of executives and administrators, their peace of mind and attempted smooth routine rudely shattered I don't know how many times a day by the impertinent, exasperating, aural alarm of ringing telephones. And I am worried, too, by the thought of the power we have put into the hands of the telephone conversationalist—that well-meaning thick-skinned addict. In a near-by coffee bar this week, I saw a cryptic message chalked up to intrigue the passer-by: "Is your emotional life upset? "—the message was just above the telephone, too. What can we do about the telephone and the telephone play-boys?

There are two possibilities I can think of: one for the Post Office's attention and necessary action, the other for the users. The Post Office could help by applying the results of an experiment which was carried out during the First World War. Someone found that whereas Army horses took fright at the sudden sound of a camp hooter, they remained calm if the long drawn-out wail was preceded by a short " peep " on the hooter. Desk-bound Man would remain calm, too, if the telephone tinkled sweetly before it rang insistently.

The suggestion for users should, I think, be taken up by an organisation like the influential Institute of Directors. Could they give a lead by getting their members to confine telephoning, as far as possible, to the afternoons? Phone-free mornings would be a boon to the majority of top and middle executives, and most of them are more approachable, even on the telephone, after they have had their lunch. If this practice acquired the force of a social convention—if it became the "done thing"—our working lives would not be so often upset. Post Office engineers and switchboard operators would take over all the headaches.

CAPRICORN

Weekly Survey

Canadian Isolation

The Gordon Royal Commission on Canada's economic prospects has now published its report in a final form. The Commission was appointed by the Liberal administration in June, 1955, but the report is released just after the Conservative landslide at the recent General Election. The tenor of the report is towards protection, especially against American competition. To this extent, therefore, the survey is closer to Conservative than Liberal economic policy.

The report parts company with Conservative policy, however, on the possibility of a switch in Canada's trade from the United States to the United Kingdom. The Commission foresees increased trade with the United States despite the dangers of increasing the dependence of Canada on the United States economy. They foresee the future of Canadian expansion as the development of secondary industries protected by import duties. It is these industries which would require particular protection from United States competition and which would in their turn have poor prospects for selling their products in the United States market.

Throughout the report there is little reference to the possibility of a formal free trade agreement between the United Kingdom and Canada on the lines briefly sketched by the Chancellor of the Exchequer and the President of the Board of Trade some months ago. Nor is there any preoccupation with the effect of the Free Trade Area in western Europe on Canadian prospects. Altogether the report seems to be mainly concerned with developing an industrial system behind tariff walls against competition from the United States, coupled with active measures to prevent the United States getting too much control through share capital and management of Canadian investment organisations and companies.

Orders Well Maintained

Orders worth more than £50 million were placed in the United Kingdom by the Royal Dutch/Shell Group of Companies last year. Of this, £12 million was for material and equipment for the maintenance and expansion of the group's United Kingdom oil refineries and for research operations in this country. The balance of £28 million was for materials, plant and machinery to be exported for use in exploration, manufacturing and related activities overseas. This compares with actual shipments from the United Kingdom during 1957 amounting to £37 million. So far, there have been few signs of retrenchment on the part of Shell or the other major oil companies, despite the very weak market for many of their products over the past six months. Planning has to be far more ahead than it is possible to anticipate cyclical fluctuations in business activity and only the broadest long-term trends can be taken into account in determining the industry's investment programme. No major supplier of materials is more confident concerning the future: demand for petroleum products is expected to go on expanding over the next decade at an even greater rate than it has done since the war. Hence the continuing high level of orders being placed, which in itself is a valuable stabilising factor in world trade.

One interesting feature of the Royal Dutch/Shell orders is that they were spread over 3,500 British firms. One firm, however, received orders of over £5 million, five others of over £1 million and 67 of over £100,000. The average value of the remainder was well below £7,000. Linepipe and oil country tubulars figured largely in this year's purchases and orders on United Kingdom mills totalled 92,600 tons, to a value of approximately £6½ million. The improvement of communications in the oilfields was an important source of business: purchases included a 350 ft radio tower for radio communications in the Lake Maracaibo area of Venezuela. Two mobile repair trucks, each fitted with radio cabin and aerial, twin searchlights and fully equipped for day and night emergency repair work in the oil fields were also supplied. A new type of equipment, air conditioned caravans, was developed specially in conjunction with Shell engineers and six of them supplied for the use of survey and exploration parties in Pakistan.

There is little doubt that a prolonged slump in demand for petroleum products would have some effect on the industry's purchase of equipment. But the reduction of oil imports by the United States must lead to a switch of purchases from dollar to sterling sources and may prove an important factor in the placing of orders during the current year.

Ghana Seeks Gold

The Ghana Trade Mission which visited this country recently laid emphasis on its desire to attract British capital. The Mission has visited Europe at a time when Aluminium Limited of Canada has just announced that it is not in a position to proceed for the time being with the Volta River scheme and does not wish to get in the way of other interested parties. Aluminium Limited is reported to have said that it is prepared to negotiate the release of its bauxite concessions, provided the Volta scheme is carried through. It is possible that this company's attitude to the Ghana project is affected by the difficulty which North American companies are having in preserving their liquid resources in the present time of industrial recession. It has been apparent, however, for some time that despite the aluminium companies' endorsement of the technical aspect of developing an aluminium plant on the Volta, there has been protracted difficulty about finding finance. Behind this again is a varying degree of enthusiasm in different quarters for the conception of the scheme as a whole.

Some time ago the Federation of British Industries issued a report on investment in West Africa which was decidedly luke-warm. To many potential investors the political risk to be undertaken is large and the economic return difficult to calculate. The big West African trading companies have sunk large sums of money particularly in Nigeria and Ghana of recent years but the impression persists that political immaturity and dependence on a few exported commodities to world markets combine to make investment in this area a hazardous business. The fact remains, however, that Ghana, for instance, is an important contributor to the Sterling Area and has now control of its own sterling balances. If the Dominion cannot find finance within the Commonwealth it may yet find it elsewhere and in this connection the latest overtures in America over the Volta scheme will be worth watching.

Towards Deflation

Sir Hugh Beaver, President of the Federation of British Industries, made reference to the general economic situation in his presidential address to the Federation last week. He said that the evidence confirmed the official view that the economic climate in this country is less inflationary than for several years past. He went on to say that the Government is now faced with the responsibility of deciding when to call a halt to the present restrictions. He himself wished to

make two points. He did not think it was possible to curtail private investment for very long without affecting future productivity of the economy as a whole.

The latest information on the prospects of reduced inflation in this country comes from the state of the American recession and the trend in capital investment in this country. The United States unemployment figures for March were only slightly worse than those for February, but March is normally a month when seasonal factors cause a sharp decrease in unemployment. There was no indication of such a change of trend and the fact that the coming of spring was able only to reduce the rate of decline in unemployment could still be ominous for the American economy.

In this country new factory plans approved for the first quarter of this year were the lowest in area for any quarter since the end of 1953. At 11·8 million sq. ft they were 2 million sq. ft less than in the last quarter of 1957. Activity in the building industry is now being heavily supported by the nationalised industries and by public authorities outside their housing programmes. The large volume of work for the nationalised sector and for public bodies is still masking the effect of a decline in housing and private factory building. It is to be expected, therefore, that unemployment in the building and construction industry will increase more rapidly than the proportionate drop in activity for it is the small contracts and the small contractors which are feeling the pinch most. Meanwhile the prices of building materials is levelling off and there are signs of increased stability in contract prices quoted for constructional work. Altogether there may be a good deal of trading difficulty for smaller contractors this year until there is a revival in factory building by private enterprise.

What's Cooking?

The Electricity Council published last week the results of the first comprehensive survey of the domestic consumers of electricity in England and Wales. It was carried out in 1955 under the aegis of the Utilisation Research Committee of the former Central Electricity Authority and Area Boards. A somewhat similar survey was carried out by the E.R.A. in 1946 and although the two are not strictly comparable some comparisons are given to show the growth in the percentage of the total number of consumers possessing a wide range of electric appliances. A firm basis will now be available for keeping under review the course of development, since the samples selected by the individual Area Boards are being increased by an appropriate proportion of all new consumers, thus forming permanent samples which can be re-surveyed periodically.

The main features of the 1955 Survey are that the average consumption of electricity per consumer rose from 1,200 kWh in 1946 to 1,540 kWh in 1955. The proportion of consumers with electric cookers (including breakfast cookers) rose from 16·6 per cent to 25·5 per cent, while over the same period the gas cooker percentage fell from 74·6 per cent to 67·2 per cent, and other cookers from 24·5 per cent to 21·3 per cent. Over this period an extensive modernisation of gas cookers took place, the percentage of modern types rising from 29·8 to 61·1 per cent. As might be expected, electric cookers have made most progress in rural areas and just over half of the rural consumers had electric cookers.

The proportion of consumers with electric water heaters doubled from 10·3 to 20·6 per cent. In 1955 slightly over 16 per cent of all consumers had immersion heaters, though some 46 per cent of them were fitted to unlagged tanks. About 40 per cent of the immersion heaters were found to be used only in the summer, an important result since it confirmed the favourable load characteristics of this type of appliance. The proportion of consumers with gas water heaters rose from 13·9 per cent in 1946 to 14·7 per cent in 1955, but solid fuel boilers continued to be the most important source of hot water though the proportion of consumers with such boilers fell from 58·7 per cent in 1946 to 56·5 per cent in 1955.

A detailed consumption analysis by statistical methods shows the average consumption per consumer possessing the appliance in question was highest in the case of full-size cookers at 1,400 kWh per annum, followed by immersion heaters at 1,200 kWh per annum, sink-heaters 750 kWh, breakfast cookers 700 kWh, space heating 600 kWh and lighting and sundry appliances 450 kWh. The report also contains an interesting classification of the statistics by region, type of meter, economic status, size of household, number of rooms and annual consumption and provides a great deal of valuable new data regarding the pattern of domestic electricity consumption.

Bear Facts

The United States General Electric Review for March, 1958, contains four reviews of Russian technology based on recent visits to the U.S.S.R. by executives of G.E. These cover metallurgy, electronics, industrial control and perspective, the last dealing with the principal changes in organisation since the 1930's. Taken together, the reports bring out the importance attached in Russia to technical education and research, but also suggest a general inferiority of Russian factories and productive equipment as compared with those in Western countries.

In the field of metallurgy, salaries are based not only on the work done but also on the numbers of degrees held. A high proportion of graduates do not take up technical work but go into jobs of supervision and administration in the metallurgical industry. The American investigators were particularly impressed at the familiarity of most Russians with technical developments in the West and pointed out that virtually every American paper of importance is translated into Russian. Moreover great importance is attached to the teaching of English to everyone who takes up metallurgy, and of German to chemistry students. It was also felt that the coupling between applied science and practice was better in Russia than in the United States.

In the field of electronics Charles L. Rouault, Consulting Engineer, Heavy Military Electronic Equipment Department of G.E., reported that contrary to general belief Russian development was not confined to narrow areas. He found that such development covered very adequately the areas of major interest to anyone in the electronics business. On the other hand, the Russian factories visited were considerably inferior to American, both as regards plant and machinery installed and amenities. Moreover civilian industry has a low priority for materials. American engineers could, however, learn a great deal from the Russians as regards the achievement of worth-while results with a minimum of equipment and of creature comforts.

The conclusions of the G.E. engineers follow very closely those reached in the report "How Good Are Soviet Engineers?" published in ENGINEERING last autumn. In particular the same views are expressed on the high standard of applied research, the adjustment of salary scales in accordance with degrees held, the keen interest with which Western work is followed, the low priority of most consumer industries, the lack of attention given to the design of many consumer products, and the inadequacy of costing systems and safety measures.

On the other hand, the report in ENGINEERING emphasised that the overall rate of technical advance was by no means consistent. Indeed in the accounting department of one large Soviet factory the abacus was still used as an aid to calculation. "How Good Are Soviet Engineers?" is now available as a reprint (price 4*s*.)

Letters to the Editor

CORIOLIS ACCELERATION

SIR, On p. 420 of your issue of 4 April, Mr. J. Pidduck gives a derivation of Coriolis acceleration "based on the relationship between torque and angular momentum."

If, however, any of your readers should tend to jib at the notion of the "moment of inertia of a particle about an axis," the following proof may be of interest. Use of the complex variable gives the two dimensional motion of a particle in a single line of analysis—completely and not inelegantly—by direct application of the second law of motion.

Thus, expressing the co-ordinates (x, y) or (r, θ), of a particle of mass m, by the complex quantity

$$\xi = x + iy = re^{i\theta}$$

and the applied forces, or reactions, similarly by

$$\chi = \mathrm{X} + i\mathrm{Y}$$

the equation of motion is

$$\chi = m\ddot{\xi}$$
$$= m(\ddot{r} + 2i\dot{r}\dot{\theta} - r\dot{\theta}^2 + ir\ddot{\theta})e^{i\theta}$$

in which the effect of the term $e^{i\theta}$ is to rotate through an angle θ the directions of the force-components, so that the real and imaginary parts of $\chi e^{-i\theta}$ are the forces R and T along and normal to the radius vector, giving

$$\mathrm{R} = m(\ddot{r} - r\dot{\theta}^2)$$
$$\mathrm{T} = m(2\dot{r}\dot{\theta} + r\ddot{\theta})$$

where the contribution $2\dot{r}\dot{\theta}$ is the Coriolis acceleration.

Yours faithfully,
E. H. BATEMAN.

Royal Aircraft Establishment,
Farnborough,
Hants.
10 April, 1958.

UNDERGRADUATE TRAINING IN NUCLEAR POWER

SIR, I am prompted by the article "Fundamental Training in Nuclear Power" by Professor J. M. Kay, on p. 394 of your issue of 28 March, to write you a follow-up on his observations on post-graduate courses in nuclear power.

These courses have attracted much attention in the last two or three years and there are several full-time courses running in this country at the moment. For young qualified engineers and applied scientists wishing to have an overall picture of the nuclear power industry, the courses are an admirable way of obtaining a thorough training. To provide the manpower for a rapidly expanding nuclear industry, these courses, pioneered by the Reactor School at Harwell, have been essential. But now that the immediate need is satisfied surely it is time that fundamental training in nuclear power should be given to undergraduates generally.

The main difficulty for engineering students is a lack of knowledge of nuclear physics. If this subject can be offered in a suitable form, so that the fundamentals are known and the general picture of the whole nuclear field can be seen, then the detailed extensions of the conventional branches of engineering to cover the special nuclear technologies can be learned on the job, accompanied by such short part-time courses of lectures as are appropriate to the particular individual.

As an example of a scheme of this kind, undergraduate students of mechanical engineering at Southampton University for the last two years have had the opportunity of taking, as one of their subjects for the Part Two B.Sc.(Eng.) examinations, a subject entitled "Nuclear Power." The syllabus sets out to give a grounding in applied nuclear physics, with sufficient general information about reactors, nuclear metallurgy and the like, to indicate the scope of the new technology. The lecture course is

Continuing Letters to the Editor

supplemented by experimental work carried out at the Atomic Energy Research Establishment at Harwell, in conjunction with the Reactor School. Students undertake experiments on the measurement of nuclear radiation, and of neutron slowing-down and diffusion. A shielding experiment is carried out on the BEPO reactor and a sub-critical natural-uranium graphite assembly is used for an exponential experiment. Visits are also made to study some of the research reactors in the establishment.

This course is now to be available to electrical as well as mechanical engineering students. Honours students may take a second year of study in the subject, and will then deal with such topics as advanced reactor physics, reactor kinetics and control, and advanced heat transfer. These students also undertake an individual project which may be related to a nuclear problem. Visiting lecturers from industrial groups and from the United Kingdom Atomic Energy Authority also contribute to lecture courses in the evenings on special topics. Students are encouraged to attend these lectures to enlarge their knowledge.

It is thought that the inclusion of nuclear power in the undergraduate course will still allow for a balanced engineering training, although obviously some work must be omitted from the conventional selection of subjects to make way for it. For mechanical engineers wishing to take nuclear studies, the omissions are obtained by a suitable pruning of the syllabuses of thermodynamics and hydraulics. Briefly the former concentrates on turbines and heat transfer, and the latter on hydraulic machinery and lubrication. Electrical engineers with nuclear interests can omit either a telecommunications course or a power and machine design course, according to whether they intend becoming " heavy " or " light current " men.

Schemes such as that mentioned should become widespread if industry is to have a steady supply of young engineers who can take nuclear problems in their stride.

Yours faithfully,
N. S. GRASSAM.

Department of Mechanical Engineering,
The University,
Southampton.
3 April, 1958.

ANODE AND POSITIVE ARE NOT SYNONYMOUS

SIR, Mr. G. H. C. Nicholls's letter on p. 419 of your issue of 4 April, interested me very much. My first reaction was " Who ever said they were? " and I agree that it is most regrettable that text-books on electricity are now appearing in which these terms are confused, showing that the authors are not clear as to the origin of the terms " anode " and " cathode." As your correspondent states, the terms electrode, anode, and cathode were originally coined by Faraday, in conjunction with two friends (one of whom was Dr. Whewell), and to refresh my memory I have looked up the matter in Faraday's *Experimental Researches in Electricity* (Everyman's Library edition), and it makes most interesting reading. After giving his reasons for the need for new terms in connection with electrochemical decomposition, Faraday says: " The anode is therefore that surface at which the electric current enters . . . The cathode is that surface at which the current leaves the decomposing body." In a footnote it is explained that anode is derived from the Greek ἄνω (upwards) and ὁδὸς (a way), and cathode from κατὰ downwards and ὁδὸς (a way).

In my student days at Finsbury Technical College, nearly 50 years ago, this matter was made perfectly clear by Professor Silvanus P. Thompson in his early lectures on electricity to first-year students, and I well remember one of his remarks: that mistakes were copied from one text-book to another by different authors. Needless to say, in his little book *Elementary Lessons in Electricity and Magnetism*—our bible—(1908 edition), he leaves no doubt in the reader's mind; for, in discussing the voltaic cell, he says: " That plate or piece of metal in a cell by which the current enters the liquid is called the ' anode '; it is that plate which is dissolved away. The plate or piece of metal by which the current leaves the cell is called the ' kathode,' it is not dissolved, and in some cases receives a deposit on its surface."

As a matter of curiosity I have pursued the subject in several old text-books. In Ganots's *Physics*, translated by E. Atkinson (1886 edition) in connection with the voltaic cell it states: " It is important not to confound the positive plate with the positive pole or electrode. The positive electrode is that connected with the negative plate, while the negative electrode is connected with the positive plate." (Unfortunately here the terms pole and electrode are used for the same thing, but it must be borne in mind that this work originally appeared in French).

In Preece and Sievewright's *Telegraphy* (1882), in describing the simple voltaic cell it is stated: " The zinc is named the positive plate or element, the copper the negative plate or element"; and a diagram is given showing clearly the current flowing from the copper to the zinc in the external circuit and from the zinc to the copper internally. Gore's *The Art of Electro-Metallurgy* (1884) also concurs in the definitions as given by Faraday.

Referring to Clerk Maxwell's *Electricity and Magnetism* (1881), we find that, after discussing the Daniell cell, he states: " The places where the current enters and leaves the electrolyte are called Electrodes. Of these, the electrode by which the current enters is called the Anode, and that by which it leaves the electrolyte is called the Cathode."

Slingo and Brooker, when describing the simple voltaic cell, in their *Electrical Engineering* (1890), say " the plate which is more or less dissolved [i.e., the zinc] is called the positive plate, the other [i.e., the copper] being called the negative plate." Watson's *Physics* (1911 edition), describing the Daniell cell, points out that the copper plate is the cathode.

The one book which I thought I could quote with certainty, T. F. Wall's *Electrical Engineering* (1921), appears to have a misprint under the description of the Daniell cell (referring to the simple cell), but agrees with Faraday's definitions under electrolysis.

Space will not allow me to refer to the considerable number of text-books in my possession, but I can assure Mr. Nicholls that the consensus of opinion is with him, although I admit I do not possess any of the recently-published books on electricity.

Yours faithfully,
J. F. PERRIN.

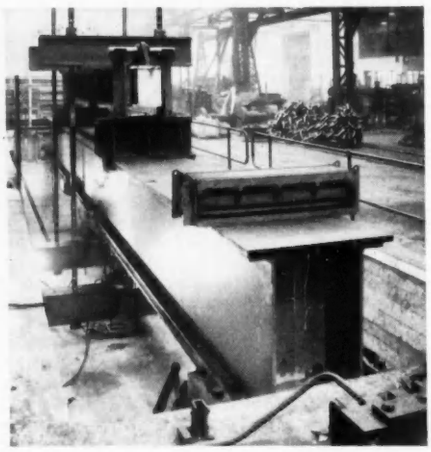
6 Cavendish Avenue,
Welling, Kent.
10 April, 1958.

Plant and Equipment

ECONOMICAL BEAM TESTING MACHINE

Built for Lloyds British Testing Company, Limited, Low Walker, Newcastle upon Tyne, by J. Samuel White and Company, Limited, Cowes, Isle of Wight, the beam testing machine shown in the accompanying illustration has the double advantage of being economical in first cost, and simple to use and maintain. It will apply loads of up to 200 tons to beams with maximum dimensions of 39 ft long, 5 ft deep and 4 ft wide.

The machine is based on a fabricated steel box girder 46 ft 6 in long, made from two



Two hydraulic jacks, two load capsules, and a simple arrangement of beams enable a load of 200 tons to be applied to a specimen beam of any length up to 39 ft, and up to 5 ft deep.

40 in by 12 in broad-flange rolled steel joists, with 1 in thick steel plates welded to the top and bottom flanges. This girder, which is supported at one end by a hinged pivot and at the other by a hinged and sliding pivot, is partly sunk in a pit for convenience of access to the beam under test. No load other than the deadweight of the machine—about 30 tons, without the specimen—is carried by two simple foundation pads.

Test loads are applied by two 100 ton hydraulic jacks mounted in cast-steel bolsters below the main girder, the bolsters being fitted with small wheels running on the upper side of the girder flange, so that the jacks can be positioned to apply the load as required. When the jacks have been moved to their loading position, the bolsters are clamped, and the jacks, acting vertically downwards, transmit a load to cross beams lying at right angles to the main girder. Tension bars working in slots in the ends of the cross beams connect them to similar beams resting on the specimen to be tested. Loads are thus applied to the specimen, and hydraulic capsules between the jacks and the lower cross beams give direct readings in tons of their magnitude. A variable-delivery pump supplies hydraulic fluid at a maximum working pressure of 6,000 lb per sq. in.

For loading beams at the neutral axis special trunnions are mounted on the main loading girder and on the underside of the top cross beam. These engage with pins attached at the neutral axis of the specimen.

FIREPROOF FLEXIBLE METALLIC HOSE

A new fireproof flexible metallic hose has been developed for aircraft fire extinguisher systems, both civil and military, which meet the stringent requirements of the British Air Registration Board and the American Civil Aeronautics Authority. The new hose is made by Power Auxiliaries Limited, Swindon.

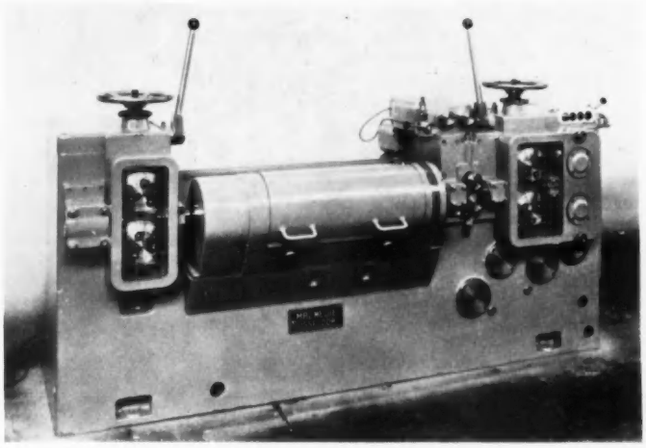
In proving tests carried out by Power Auxiliaries, the hose was subjected for 15 minutes under vibration to the blast of three gas burners at a temperature of 2,200° F. No cooling fluid was passed through the hose during the test. A 12 lb Graviner fire extinguisher was then discharged through the hose which, despite the thermal shock of this sudden flow of cool fluid, remained fully intact. Later tests showed the hose to be fit for service and able to withstand an air-under-water pressure of 1,000 lb per sq. in.

Continuing **Plant and Equipment**

STRAIGHTENING AND CUTTING COILED ROD

Stuart Davis Limited, Much Park Street, Coventry, have announced the introduction of a new machine to the German-made Malmedie range. The machine, which Stuart Davis are marketing in Great Britain, is for high-speed straightening and cutting of rod from coils. It will cut rod from 0·393 in to 0·787 in diameter, the length of piece being infinitely variable between the limits of 9 ft and 64 ft.

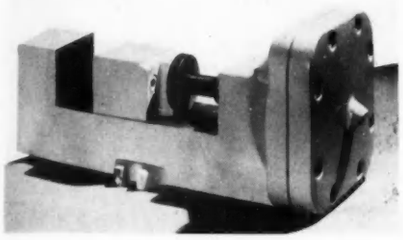
Straightening is carried out at 200, 300 or 400 ft a minute and there is a 25 h.p. motor to drive the spinner, in addition to a 20 h.p. motor which provides the main drive for the machine. The design allows for horizontal and vertical straightening rolls to be fitted instead of the spinner if desired, and a bundling bench to suit the cut lengths is available.



Rod from coils is straightened and cut to predetermined lengths in this machine.

AIR VICE

A general-purpose vice for use on the bench or on a machine tool has been introduced by Dyson and Nalson, Viaduct-street, Huddersfield. It is intended for repetition work and is operated by compressed air. As will be seen from the illustration, the opening of the moving jaw can be adjusted by a screw and nut. The power travel of the jaw is ½ in and the maximum opening is 3 in. The clamping force can be varied from a light squeeze up to 2,200 lb as desired.



Compressed air can give clamping forces up to 2,200 lb in this quick-acting vice.

Operation can be by a foot switch which leaves the operator with both hands free; a valve for this purpose is available. The maximum air pressure that can be used is 150 lb per sq. in and the consumption is very small.

ULTRASONIC CLEANING PLANT

Vacuum Technique Avoids Air Pockets

Metal cleaning plant using ultra-sonics coupled with a vacuum technique as developed by Technochemie of Switzerland is now available in this country from the Electro-Chemical Engineering Company Limited, Woking, Surrey. The main advantages are that air pockets are eliminated allowing the solvent to reach all parts of the work and, since air is also removed from the solvent itself, cavitation is more effective. This gives better cleaning of small blind holes. Two frequencies are used, 400 kilocycles and 40 kilocycles, operating through barium titanate Piezo-electric transducers.

The cleaning sequence usually used is as follows:—first there is a pre-cleaning operation with perchlorethylene or trichlorethylene with continuous filtration. Then follows the ultrasonic stage with or without vacuum, but with continuous filtration using the same solvent. There follows a continuously filtered rinse also using the same solvent, a vapour de-grease process and finally a drying stage which may include the use of vibration, infra-red heating and a stream of hot filtered air. All these processes may be incorporated in hand or fully automatic machines.

MARINE RADAR

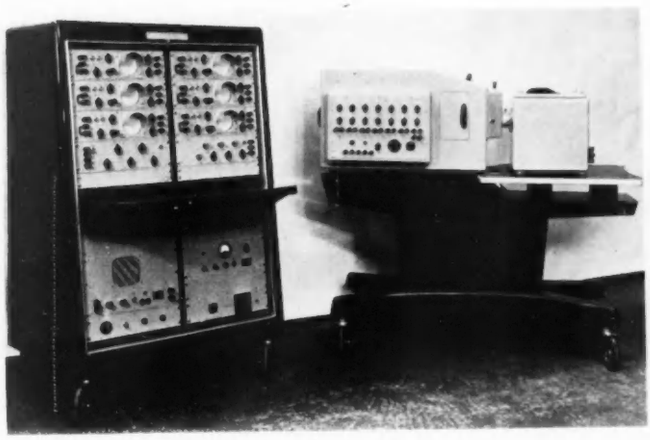
The British Thomson-Houston Company, Limited, Rugby, have recently announced the introduction of their new commercial radar equipment—called the Escort. It comprises four main units and can be fitted to a wide range of merchant ships—from ocean liners to fishing trawlers. A 12 in cathode ray tube is used.

Several forms of radar presentation can be selected by a switch: "chart plan" presentation, in which the centre of the rotating trace (the ship's position) travels across the face of the tube with a speed and direction corresponding to the movement of the ship: "north upwards" presentation, in which the chart-plan generators are switched off and the top of the display represents north; and "ship's head upwards," in which the chart-plan generators are switched off and the top of the display represents the bearing of the ship's bow. An auto-trim feature corrects the picture orientation for the last two presentations. Combined electronic and mechanical bearing markers enable the bearing of echoes to be read from one scale around the display tube, irrespective of whether the picture is centred or off-centred. The display provides seven ranges, from ¾ to 48 miles. A shorter duration pulse is incorporated for a clearer picture at close ranges. The operating frequency is 9,420-9,500 Mc/s and the peak power output is 45 kW.

MULTI-CHANNEL OSCILLOGRAPH

A new type of cathode-ray oscillograph has been developed by Southern Instruments Oscillograph Division to provide a flexible multi-channel recording equipment. The 3 in diameter recording tubes are separate from the main equipment, housed in a cabinet to which the camera and optical system are fitted. Power supplies and driving voltages are supplied to a master distribution panel in this unit by means of flexible cables from an amplifier console. The illustration shows the equipment, called the MUR6 Universal Oscillograph.

Within the recording unit the tubes are mounted in adjustable clamps on a short steel column. This is fixed to a base sliding on rails and enables the tubes to be moved towards or away from the camera lens in a precise manner. Thus the user can alter the conditions with ease and photograph as many of the tube faces as he needs. It is obviously possible to install a simple equipment in the first place and subsequently to add tubes and amplifiers to provide further channels with a minimum of expense and inconvenience. Two models are available, providing up to six and twelve channels, respectively, with time marking. The firm is at Camberley, Surrey.



For multi-channel recording, each of the cathode ray tubes can be moved towards or away from the camera lens in a precise manner.

Continuing **Plant and Equipment**

For the FACTORY

THE SIXTH Factory Equipment Exhibition was opened at Earls Court, London, on Monday, 14 April, by Sir David Eccles, the President of the Board of Trade. Once again larger than the previous one, the floor space has been increased by 25 per cent. As an integral part this year there is a section devoted to insulation, a subject much to the fore in factory construction at the moment as the Thermal Insulation (Industrial Buildings) Act comes into force next January. In connection with the exhibition there was also a one day conference on the subject, opened by Mr. Nabarro, M.P., the original promoter of the Act, on 17 April. There was also a section displaying many types of heating by oil fuel. In this article we describe a few of the many items on show.

INSULATING WINDOWS

In the thermal insulation section of the exhibition, Pilkington Brothers, Limited, St. Helens, Lancashire, were showing examples of their Insulight hollow glass blocks, which will transmit natural light but are resistant to the passage of heat. The blocks consist of two moulded sections sealed together by a direct glass to glass fusion joint, enclosing air at reduced pressure. As a result, light is transmitted with good diffusion and there is a substantial reduction in heat loss in comparison with normal glazing. Equally they impede the passage of heat inwards. Thermal tests at the Building Research Station gave a transmission co-efficient of 0·44 B.t.u. per sq. ft per hour per ° F—comparable to that of a nine-inch brick wall. One use of these units, in conjunction with armour plate glass, has been in the pulpits of slab rolling mills where they give a great improvement to the comfort of the operators combined with protection from flying chips of hot metal.

MOVING GOODS UP STAIRS

The "Stepmaster" is a hand truck that can go up stairs almost as easily as it can run along the level. It is being marketed in this country by Industrial Trucks, Limited, Essex Road, Acton, London, W.3, and was shown on their stand. Fig. 1 shows it in the normal wheeling position and Fig. 2 shows the action for negotiating stairs.

When running on the level, a lever catch holds the roller tracks against the back of the truck, clear of the ground. Releasing this lever allows the tracks to drop, and they are then held in the open position by a plate with a slot and catch mechanism. The length of the tracks is such that they span the stair treads and form a running surface on the crawler principle. Adjustment is provided to take up any slack in the belts themselves. The change from track to wheels and vice versa is a matter of seconds only, so that no time is lost when a step is encountered. The truck is made of light alloy but can carry loads up to one hundredweight. One man can easily manage this load even when going up stairs.

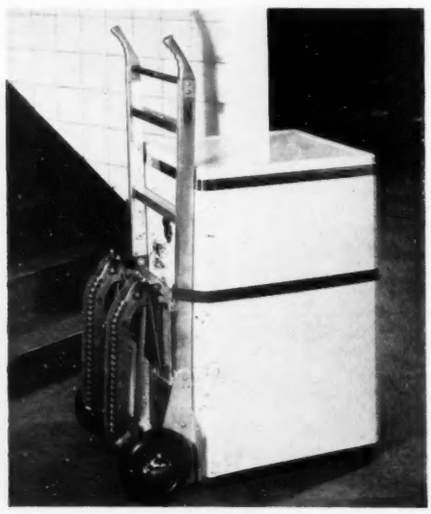


Fig. 1 On level ground the "Stepmaster" runs on cushioned wheels.

Fig. 2 For negotiating stairs the tracks are lowered to form a crawler track.

BOTTLE PRINTING MACHINE

On the stand of Gordon and Gotch Limited, 75-79 Farringdon Street, London, E.C.4, was the SPS Rotascreen made by Siebdruckgerate Von Holzschuher KG. Fully automatic, it can be used to print a wide range of containers including glass and polyethylene bottles, jars, pots, or tins. It will take any size between $\frac{3}{4}$ in and 3 in in diameter and from $3\frac{1}{8}$ in to $11\frac{3}{4}$ in long. A servo motor provides automatic centring, and automatic feed is obtained by a star feeder. Stencils can be retouched without altering the register. For printing flexible containers there is a hand feeding attachment.

The machine works from a 220 volt supply and consumes 90 watts. It requires a floor space of 24 in by 16 in, not including the delivery conveyor, and weighs about 180 lb. The output is up to 2,500 impressions per hour.

A smaller model, the SPS Minor, was also on show which screen prints on inflexible packs both round and square up to a maximum depth of 1 in and a maximum size of $4\frac{3}{4}$ in by $4\frac{1}{2}$ in. Articles are automatically fed into the machine from a hopper and speeds of up to 3,000 per hour are obtainable. The hopper can easily be changed to suit the type of article to be printed, and the minimum thickness of material that can be handled is $\frac{1}{8}$ in. The maximum printing area is the maximum size of the article, and the minimum size is $\frac{3}{4}$ in by $1\frac{1}{2}$ in.

ASBESTOS SHEET

On the stand of Marinite Limited, 114 Park Street, London, W.1, were examples of how the use of Marinite asbestos sheet, originally developed for marine purposes, has grown in industry. One exhibit was a sheet that had been submitted to 40 weeks continuous flame testing to incandescence (700 to 800° C) by the Industrial Laboratory of the North Thames Gas Board, with very little effect to the surface. Details of one-, two- and three-layer construction of tanks and similar vessels were shown and there were photographs of Marinite launders for conducting molten aluminium.

Cape Building Products Limited, of the same address, were exhibiting "Asbestolux" insulation board which has been proved in the field to be non-combustible. Tests have included the firing of a full-scale three-bay factory structure, lined with Asbestolux, when the structure stood up to temperatures in excess of the six-hour test requirements.

TAPES, SHEETS AND FLOORINGS

On a 2,000 sq. ft stand, the Minnesota Mining and Manufacturing Company Limited, 3M House, 103 Wigmore Street, London, W.1, were showing a fully representative selection of their range of products. Items on view included tapes for packaging and recording, sheet with reflecting properties, non-slip floor covering, and copying and printing equipment.

The strongest of the packaging tapes is the number 880 filament type which has a tensile strength of 180 lb for each inch of width. Magnetic recording tapes include the 150 polyester Extraplay designed to fit most popular dictating machines, but which provides about 50 per cent longer recording time for the same size of spool. It is available in spools of 300, 900, 1,275, 1,800 and 2,400 ft. Wrapping tapes complete the picture.

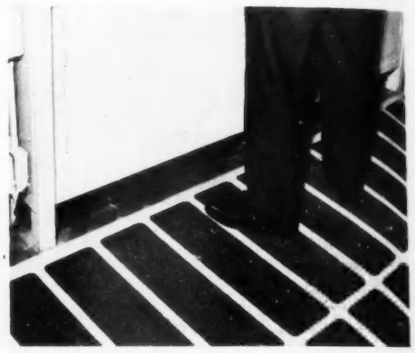


Fig. 3 "Safety-Walk Wetordry" can be laid on most floors and is unaffected by weather, oil, petrol or heat.

Shown in Fig. 3 is the floor covering material. Known as the "Safety-Walk Wetordry," it consists of extremely hard mineral grains surface-coated on a heavy fabric. It is weatherproof and unaffected by oil, petrol or heat; it can be laid on most surfaces. The material is supplied either as strips or in rolls. There are three types: the first is for use on concrete or rough surfaces from which moisture cannot be eliminated even during application, and the floor must first be coated with an adhesive. Type B is for most clean dry surfaces and is coated with a pressure-sensitive adhesive, and type D is a non-spark version of B produced for special conditions.

"Scotchlite," the reflecting material, has an integral layer of minute glass spheres bonded to one side of a durable film. The other side is coated with a pressure-sensitive adhesive that will hold on almost any smooth non-porous surface. The reflective power is about 175 times that of white paint and the reflections are visible at angles of incidence up to 75°. This means that road signs made from the material can be seen from angles that would give no reflection from the conventional cats-eyes. Car headlights can give reflections from as far as half a mile. Recent tests have been conducted which clearly showed the advantages. In addition, the reflecting surface can be made in different colours offering a code system for exits or mustering points in the dark. At the exhibition it was demonstrated that the reflections could be easily seen through smoke.

BRITISH STANDS AT BRUSSELS

LAST Wednesday the Brussels Universal and International Exhibition opened. It covers 500 acres. Official estimates suggest that 35 million visitors may be expected, while unofficial estimates speculate at 50 million. Whatever the number, there is no lack of interest for those who decide to go.

It is too early yet to give a full account of the equipment and models on view, but it is possible to give a brief summary of some of the British exhibits. Later articles will cover other aspects of the exhibition.

The Board of Trade, in agreement with the United Kingdom Atomic Energy Authority, arranged that its major contribution to nuclear energy publicity in 1958 exhibitions should be the present stand in the British industries pavilion. Simple diagrams show why the discovery of nuclear energy at the present moment is so important to the world. Britain's achievements in producing the world's first commercial power station is illustrated by a model of Calder Hall and a device showing the number of megawatts supplied to the national grid to date. Four models of new atomic power stations show the developments taking place in the Calder Hall type of station. The display also shows the research in progress to evolve new and more efficient forms of fission reactor. This is done by a large model of the Dounreay fast breeder reactor, a model of a high-temperature gas-cooled reactor, and a diagram of an aqueous homogeneous reactor. The exhibit has concentrated on aspects of nuclear power which are expected to lead to sales of equipment during the next 10 or 20 years, rather than on long-term research. For that reason the emphasis is on the different types of fission reactor rather than on the prospects of evolving a fusion reactor. But to complete the picture, the last item in the display is an illuminated model of Zeta.

The theme of the English Electric-Babcock and Wilcox-Taylor Woodrow Atomic Power group is the design and building of the 500 MW atomic power station at Hinkley Point. The stand structure itself is of unusual design—a central office is suspended, like a giant lantern, from an arched roof of copper-anodised aluminium. Immediately below the "lantern" the central exhibit is an animated sectional model, on a base 3 ft square, of one of the reactor group buildings at Hinkley Point, in which the flow of coolant gas is traced in coloured lighting.

The visitor approaches the model through converging display panels and the background to the model is a large painting, by Claude Buckie, portraying the station in an advanced stage of construction, and showing such activities as the moving of electrical plant into the turbine hall and the lifting into position of one of the steam generating units by the Goliath crane.

A sub-station, which not only supplies electric power and light to the two British pavilions but also is itself a working exhibit, has been equipped by the English Electric Company Limited and installed by the official electrical contractors, James Kilpatrick and Sons Limited. The sub-station, at the north end of the British industries pavilion, has a glass front to permit the whole of the equipment to be seen in operation. It has a capacity of 1 MVA and takes its supply from a ring main. Two 500 kVA 11,000/415 V, oil-cooled transformers feed on to a medium-voltage switchboard comprising two 800 A air circuit breakers and 22 outgoing fuse switches.

On the stand of the Nuclear Power Plant Company a model of the atomic power station being built by the company is shown. Reactor operation is simulated by movement of the control rods. When active the core is illuminated in red; upon shut down, the colour changes to green. One of the boilers is sectioned to show a representation of the tubing.

The display by Standard Telephones and Cables Limited aims to show the contribution made by the company to the development of telecommunications throughout the world. Included among the exhibits is a submerged two-way telephone repeater, of the type to be installed for the Anglo-Belgian submarine cable system put into service for the exhibition—for which S.T.C. and their associates, the Bell Telephone Manufacturing Company, Antwerp, are responsible. Other exhibits include a demonstration of "Tacan," the air navigation system, the Stantec Zebra digital computer, and super-high-frequency radio links for television and multi-channel telephone communication.

Rolls-Royce Limited have a representative range of their products, with the exception of a motor car, on show in the British industries pavilion. A diesel of the type used in earth moving, trucking, marine, oil-field equipment, and rail transport installation is displayed, and also an 8-cylinder petrol unit, similar to those in service in many parts of the world in fire appliances, luxury coaches, power packs, and other equipment. Prop-jet and turbo-jet engines are displayed. The Conway, shown in the illustration, is a by-pass turbo-jet with 16,500 lb static thrust. It will power the Douglas DC-8's ordered by Trans Canada Airlines, and has in fact been specified by five major airlines to power American-built transports.

On their stand, Renolds Chains Limited are showing a selection from their range of roller transmission chains, standard stock series chain drives, and A.S.A. roller chain drives. The Coventry Mark 5 steel roller chains, with attachments and wheels, are included, together with chain and flexible couplings, chain tools, and the sprag clutch. Cycle, moped and motor-cycle chains and automobile timing chains are also prominently displayed. A feature of the stand is a multi-lingual sound system whereby visitors obtain a summary of the firm's products in any one of five languages.

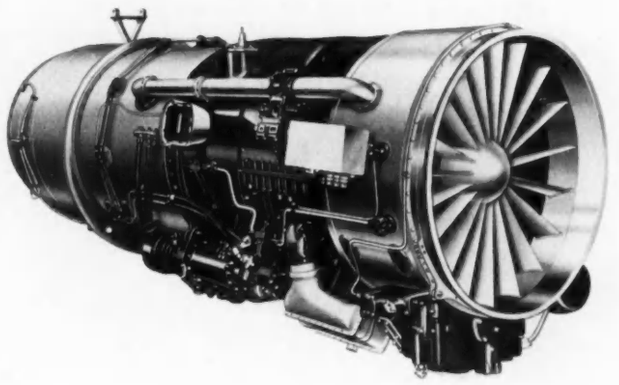
The Agricultural Engineering Association Limited, has an exhibit in the smaller pavilion adjoining the British industries pavilion, alongside the exhibit of the City of London. The stand occupies an area of about 800 sq. ft and includes over 100 coloured reproductions of some of the British agricultural tractors and machinery, together with a series of nine maps of different parts of the world showing tractor populations, principal crops and farming systems.

Many types of bearings are being displayed by British Timken Limited. They vary from a four-row rolling mill tapered roller bearing, weighing 3½ tons, to a miniature bearing. The stand is 30 ft long and along its perimeter are illuminated colour transparencies showing various departments and machines used by the firm, and the application of their bearings.

On a prominent island site immediately left of the main entrance of the British industries pavilion is the British Iron and Steel Federation's double-decker exhibit. It is an all-steel structure, consisting of a system of columns, channels and castellated beams. The first floor accommodates an enquiry hall, offices, and a lounge with facilities for refreshments, where visitors can seek information from the staff.

The ground floor, together with the outer walls of the first floor, is entirely devoted to the exhibition, with the exception of a reception area. The introductory captions explain the development of the industry. The other main captions cover the quality and performance of British steels. There are about 60 exhibits, ranging from a Bristol Olympus turbo-jet engine to the latest stainless steel tea and coffee service. Transparencies, models, including a model of the Durgapur steelworks, and films complete the presentation.

The stand of the Darlington Group of companies is of two storeys, with a lounge and reception room above, divided up between three of the eight firms in the group. The Chemical and Insulating Company Limited, which processes dolomite limestone to produce a wide range of magnesia chemicals and insulating materials, is showing a selection of its products mounted on a base representing a mass of dolomite. Alongside the chemicals is shown some of the manufactured articles in which they are used, while the insulating materials are linked visually with the display of work of the Darlington Insulation Company Limited—four models of recent insulation contracts carried out—Calder Hall A and B power stations, the Stella North power station, the Esso Fawley oil refinery, and the Shell oil tanker, S.T.S. Vola. The display of the British Refrasil Company Limited, the third company, consists of a number of back-lit colour transparencies, illustrating the use of Refrasil as a thermal and electrical insulant in aircraft jet engines, marine and land gas-turbines, and a number of other industrial applications.



The Rolls-Royce Conway by-pass turbo-jet, one of the British exhibits at Brussels.

At the stand of Imperial Chemical Industries, part of the display is a picture gallery of the numerous chemical pioneers of British stock—from Robert Boyle (1627-91) to Sir Alexander Fleming (1881-1955). Among the many exhibits is "Terylene" which provided the ropes for the Trans-Antarctic Expedition, and "Alkathene," an insulant used in radar and in the transatlantic telephone cable. Indications are given on the stand of development work on titanium and on metals for use in nuclear power plants. The company's range of paint products are also featured, as are the industrial catalysts made by the Billingham Division.

The development of the Distillers group of companies is told on their stand. This is the first time that the newer D.C.L. industrial organisations have joined with the older potable companies in a combined display covering the whole of distillers' interests. Many famous brands of whisky and gin are displayed. Other sections of the stand are devoted to engineering equipment, including D.C.L. bursting discs for the protection of pressure systems, and metering pumps with micrometer stroke adjustment. Displays show how synthetic resins and plastics are replacing traditional materials in many fields. The long playing gramophone record and non-inflammable conveyor belting are among the products whose developments have been linked with the Distillers Plastics Group.

Continuing **Plant and Equipment**

INSTRUMENTATION AND CONTROL ON SHOW

On Wednesday the President of the Board of Trade, Sir David Eccles, K.C.V.O., opened the second Instruments, Electronics and Automation Exhibition at Olympia. This year, the show is international, and in addition to more than 250 British exhibitors, there are representative manufacturers from the European Continent and the United States. The sponsors of the exhibition, which remains open until 25 April, are B.E.A.M.A, B.I.M.C.A.M, the British Lampblown Scientific Glassware Manufacturers' Association, the Drawing Office Material Manufacturers' and Dealers' Association, S.I.M.A, and—a newcomer this year—the Radio Communication and Electronic Engineering Association. This list of sponsors gives some indication of the wide range of products that can be seen at the exhibition, which range from miniature components to complete control and sequencing systems, from drawing-office equipment to nuclear-power instrumentation. In the descriptions of individual items which follow, we shall confine ourselves mainly to instruments and control-system components for the manufacturing industries.

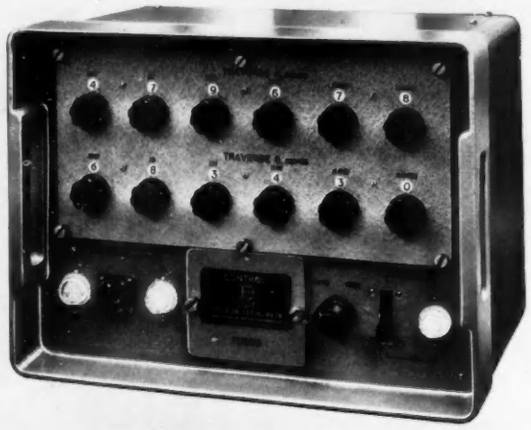


Fig. 1 (left) Control unit for machine-tool automatic co-ordinate setting equipment. Ekco Electronics Ltd.

Fig. 2 (right) Rotary switch for information sampling. Vactric (Control Equipment) Ltd.

SEQUENCE CONTROL

On the stand of Mullard Limited a new system of sequence switching for the automatic control of transfer machines—and other machines performing a number of sequential operations, batch counters, and so on—is demonstrated. The new system, it is claimed, gives a much greater degree of reliability, by avoiding the use of electrical relays, relying instead on transistor logic circuits to perform the required switching operations. The benefits conferred by transistors in this application are numerous. Inherently, transistors are reliable devices; they can be switched faster than relays; unlike relays, their life is independent of the number of operations they perform; they are compact, and require very little power. In complex installations involving large numbers of logic circuits the transistor system will also have economic advantages.

In applying transistors to control-switching circuits, the logic elements of the digital computer are used: "and," "or" and "not," with "memory," "delay" and "counter" as ancillaries. With these elements, a control system to meet any requirements can be devised. Any logic element that is "and" for one phase of signal is "or" for the other phase. This fact, coupled with the transistor's inherent phase change in the grounded emitter configuration, enables a single circuit to be used for both "and" and "or" elements. Such circuits form the basic units of the Mullard system. The circuit can also be used as an inverter, if necessary, and two combined to form a bistable "memory" to replace a latching relay. With the addition of steering diodes the bistable becomes a "counter."

Up to six input and six output circuits may be connected to one basic unit. The inputs may be derived from push-buttons, photo-cells or any type of transducer providing the small amount of power needed to switch a transistor. The output circuits give sufficient power to operate inductive loads (clutches, motors, large contactors, and so on) of up to 36 watts rating, or non-inductive loads (for example, indicator lamps) up to 50 watts. The system makes use of printed circuitry, with up to 12 basic logic units accommodated on one printed board. An appropriate number of boards are mounted, rather in the manner of pages in a book, in a neat metal case to form a compact single piece of equipment. The "book and page" method of mounting gives easy access to any particular group of units.

Mullard are also demonstrating a new high-precision measuring system suitable for machine-tool control; the system embodies the principles and basic accuracies of the normal lead-screw and nut system, but relies on the inductive or capacitative pick-up of electrical signals and thereby avoids physical contact between nut and lead screw, eliminating wear and friction. A longer nut may thus be used and greater accuracy achieved due to the averaging of the lead-screw pitch errors.

AUTOMATIC MACHINE TOOL SETTING

Last year Ekco Electronics Limited showed a prototype equipment for providing automatic co-ordinate setting facilities on existing machine tools. This year, the production version is being demonstrated in conjunction with a punched-card information storage system. The basic system comprises a traverse unit for each lead screw and a combined control unit (Fig. 1) for both traverses. The equipment will automatically set a 10 t.p.i. lead screw to within 1/500 of a single turn and may control up to 1,000 turns. Various lead screw pitches are converted by gearing to present a standard 10 t.p.i. pitch to the measuring system. In this way, a reset accuracy of 1/500 of a turn represents 0·0002 in linear movement of the work table. The equipment can be used with any rotating shaft and is therefore equally suitable for controlling radial tables, etc. The Ekco machine tool control equipment has been designed for rugged machine shop use, and for maintenance by the average works electrician, employing no thermionic valves and providing built-in checking circuits to speed up "trouble-shooting" and to simplify calibration.

GUIDANCE FOR POWERED TRUCKS

The latest contribution to automation by E.M.I. Electronics Limited is a guidance system for the automatic control of powered trolleys and trucks in factories and warehouses, eliminating the need for a skilled driver. The system is based on the principle of magnetic induction. Over the desired route a wire is laid—or buried if the route is permanent—and a current passed through the wire sets up a magnetic field which is detected by two sensing coils mounted on the front of the trolley. Spaced slightly apart, the coils form part of a closed servo loop which controls the steering gear. When the trolley is on course the current induced into each sensing coil is equal and therefore does not actuate the servo system. However, as soon as the trolley tends to wander from its course, the current induced in the sensing coils becomes unbalanced and immediately the servo system restores the trolley to its intended path. Stopping and starting from one or more remote control points is provided; several trolleys may be operated independently over the same route with facilities for automatically selecting branch routes; and automatic stopping controls are fitted which operate either if the trolley's path is obstructed or if a failure occurs in the guidance system.

Typical applications are: in warehouses, where the arrangement of stores is continually changing due to seasonal requirement; at airports, parcel-sorting offices, railway goods yards and coal mines; and at nuclear energy establishments, where it may be necessary to pass material through potentially dangerous areas.

ROTARY SWITCH

A new range of high-speed rotary switches, designed to fulfil many of the requirements now demanded by remotely operated systems, is shown by Vactric (Control Equipment) Limited. It has already solved many of the problems usually associated with telemetry work, and is finding considerable use in such diverse applications as d.c. signal chopping, wave-form generation, amplifier stabilisation, low-level sampling of strain-gauge and thermo-couple signals, and in other high-speed or low-speed applications where information is sampled. The contact plate is made by a photographic process, and complete repeatability is therefore ensured. The wiper pressure is low, compatible with contact-

Automobile Engineering

ROLLS-ROYCE AIR CONDITIONING SYSTEM

Some time ago Rolls-Royce were offering an air conditioning system of American design as optional equipment on cars used in hot climates but they later introduced a lighter, more compact system of their own design for Rolls-Royce and Bentley cars intended for export. This equipment is now available on the home market. It had previously been argued that a temperature difference greater than 15° F might produce thermal shock and possible nausea, but following a visit by senior personnel to Texas last summer, the new system was designed with a big reserve of capacity in order to create acceptable conditions in a very short time after the car has been parked in the sun, and a temperature difference up to 30° F is obtainable.

The need for air conditioning has been increased by high cruising speeds which make it uncomfortable to run with the windows open, and even in temperate climates the system has been found to increase comfort by reducing humidity.

The refrigerator unit is a vapour compression type using dichlorodifluoromethane (Freon 12) and has a maximum capacity of 600 B.t.u. per min. The gas is compressed by an engine-driven two-cylinder pump and passed to a condenser mounted in front of the car's radiator, from which it passes in liquid form at near ambient temperature to an expansion valve and thence to the evaporator in the luggage trunk, where it draws heat from the air supplied to the interior of the car. At cruising conditions the refrigerant compressor requires 3 to 4 h.p. and is driven by a twin belt drive, with an Eaton electromagnetic clutch incorporated in the pulley so that it can be switched off when not required.

Once the car interior has been cooled to 20 to 30° F below ambient temperature, excess refrigeration capacity must be dispersed. This is achieved by tapping off some of the gas from part way down the condenser and passing it through a control valve into the pipe line between evaporator and compressor. The valve is controlled by depression on the inlet side of the compressor. The driver controls the temperature by varying the speed of the air blowers, which have a maximum capacity of 400 cu. ft per min.

To minimise heat transfer to the car's interior, the roof is insulated and there are more extensive shields between exhaust system and car floor.

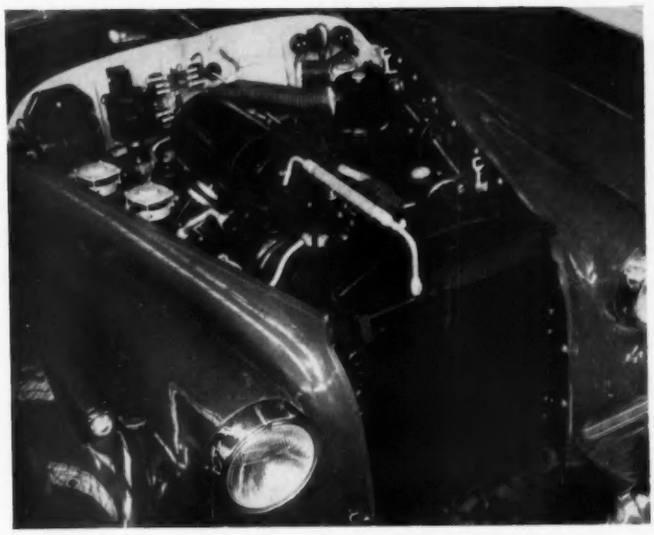


Fig. 1 Another auxiliary unit for Bentleys and Rolls is a refrigerating plant for interior cooling. The twin-cylinder compressor adds another item to the power house within the bonnet, and absorbs another 4 h.p. from the engine. The condenser is mounted in front of the radiator.

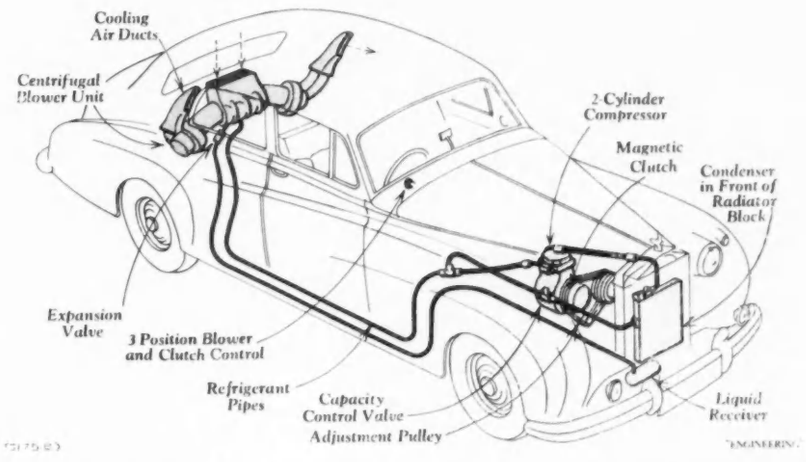


Fig. 2 The complete system uses Freon as the working fluid. Twin electric centrifugal blowers draw in air through a grid in the parcels shelf and return it to the car after cooling.

The complete system, with the necessary chassis modifications, weighs only 150 lb. It is controlled by a single switch on the facia which operates the magnetic clutch and has three positions to govern the speed of the air blower. As the condenser masks the engine radiator, the cooling system is pressurised sufficiently to compensate for the loss of cooling capacity.

Continuing Instrumentation and Control on Show

wiper bounce, and because of this, several banks may be ganged together on a common shaft, utilising the 1 in diameter motor shown in Fig. 2. In high-frequency systems where intercoupling between channels is difficult to eradicate, this type of switch provides the minimum possible coupling between segments.

The switch which weighs 80 grams, has a life in excess of 100 hours at 6,000 r.p.m., and approximately 1,000 hours at 600 r.p.m. It is available as a 24 pole or 48 pole switch, break-before-make, or make-before-break. The on-off ratio is 10 : 1 and it has a timing accuracy of ± 6 min per pole. Switches are available with scanning speeds from 50 r.p.m. to 12,000 r.p.m. The power consumption depends on the motor; for the design illustrated it is about 4 watts. The voltage is 6 V-24 V for d.c. motors, or 20 V-115 V 400 c.p.s. for a.c. motors.

On the Vactric stand are also to be seen a wide variety of a.c. and d.c. servo components, including totally enclosed and lubricated servo gearheads in speed reduction ratios from 20:1 to 600:1.

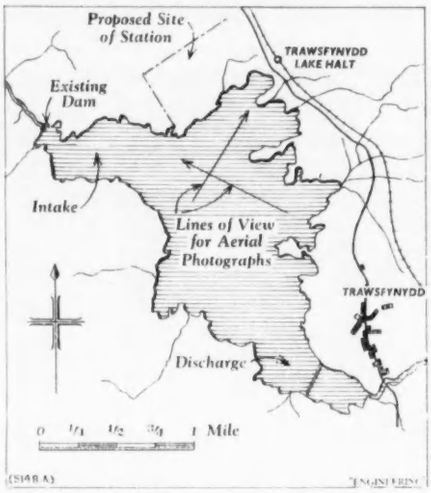
AUTOMATIC DIP-SOLDERING MACHINE

On the Ministry of Supply stand, an automatic dip-soldering machine for the production of printed circuits is displayed by the Signals Research and Development Establishment. It can solder more than 100 points on a printed wiring board cleanly in less than 10 seconds. The printed wiring board consists essentially of an insulating board carrying a series of copper strips which replace the conventional wiring between components. The components are mounted on the board on the opposite side to the copper strips, with the component wire terminations passing through holes in the board and copper strips. As all the joints to be made are in one plane, the board is suitable for multiple soldering. In operation, the board to be soldered is loaded into an adjustable carriage, which is pivoted in an outer frame. A low-frequency vibration is applied to the board just before lowering it to the surface of the solder and continuing to the end of the cycle, when the board is returned to its original position.

The time of contact between board and solder bath is adjustable between the range of 6-10 sec, and is automatically controlled. This eliminates such failings as blistering of the insulating board and destruction of bond between copper strips and insulating board. The vibration applied to the board eliminates "dry" joints, solder bridging, "stalactites," etc. By the application of a marking solution, solder may be deposited only on predetermined areas; this effects solder economy, and reduced spacing between adjacent lines (e.g., coils) may be used. In its present form, the machine will accommodate varying sizes of board up to a maximum of 9 in by 7½ in, and is capable of production rates in excess of 100 boards per hour.

The addresses of the firms mentioned are: Ekco Electronics Limited, Southend-on-Sea; E.M.I. Electronics Limited, Hayes, Middlesex; Mullard Limited, Mullard House, Tollington Place, London, W.C.1; Vactric (Control Equipment) Limited, 196 Sloane Street, London, S.W.1.

FOR NUCLEAR POWER:



Lake Trawsfynydd, showing the proposed site of the power station. The arrows indicate the direction of viewing for the two aerial photographs.

Will a nuclear power station be built on the edge of Lake Trawsfynydd in the centre of the Snowdonia National Park? An early decision is expected from the Minister of Power, Lord Mills, now that Parliament has reassembled after the Easter Recess. The Central Electricity Generating Board have asked permission to build a nuclear station of between 400 and 500 MW capacity on the edge of the lake. Early in February, a public inquiry was held in the village hall of Trawsfynydd and the Minister's decision will be based on the report of the Inspector who presided at the inquiry.

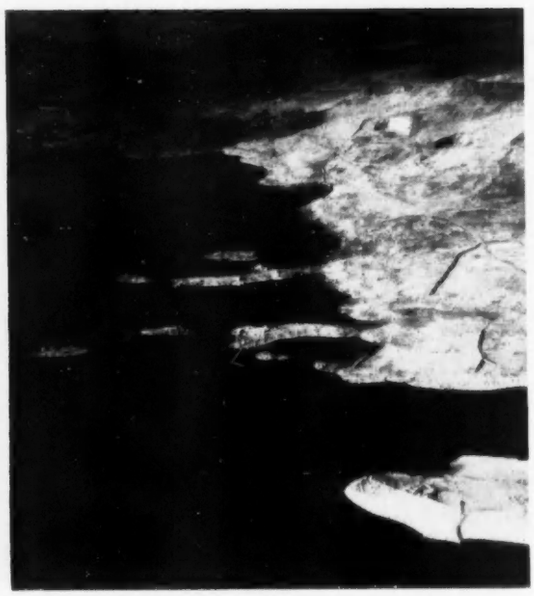
The board's case was that the site was, to all intents and purposes, the only one that was suitable to meet the expected electrical load in the Birkenhead-Liverpool area; and that every effort would be made to minimise any detrimental effect which the siting of such a station in such an area might be thought to have. The objectors' case was that the proposal contravened the principle which brought the National Parks into being; and, in particular, that the presence of the buildings of the station, and of the associated transmission lines, would detract from the natural beauty of the region, reducing its attractions for those seeking pleasure and relaxation there. Questions were also asked about the latent dangers to the local inhabitants.

It is the function of the C.E.G.B. to make electrical power available to meet the country's needs by the most economical means. To this end, the country is divided into a number of regions, some of which (like the East Midlands) have a sufficiency of indigenous coal that, converted, will meet the local electrical load. Other regions, however, particularly London and the South-east, and Merseyside, are "current-deficient," and have nothing like the coal resources locally to meet the load.

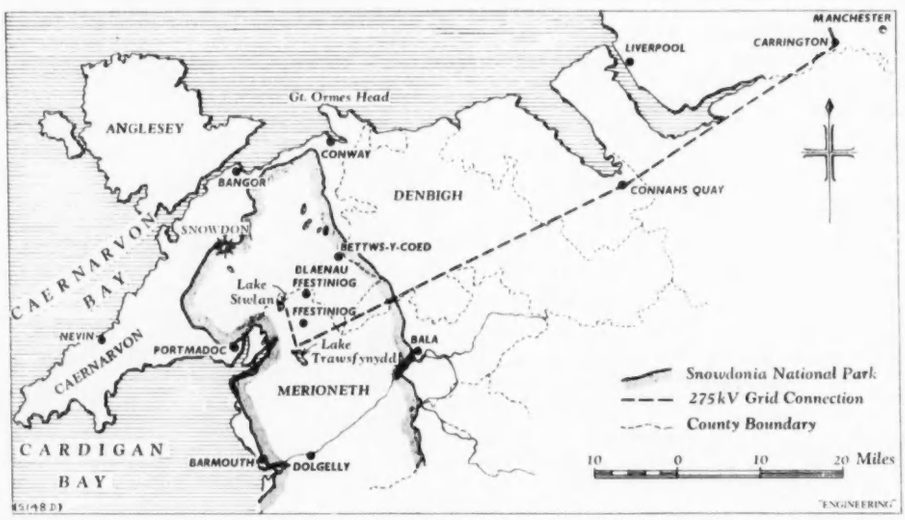
For the London and South-east area, and for the Merseyside area, power can be generated economically by nuclear power stations, of the Calder Hall type, if adequate sites can be found. In this context, for a site to be adequate, there must be a sufficient quantity of cooling water available, the sub-strata must be such as to be able to sustain the foundation loads induced by the reactors, shields and heat exchangers, and (to satisfy Government policy on siting such stations) be in an area of low population density. If it is accepted that the foundation problem can always be overcome, it remains to find isolated localities where sufficient water is available. To-day, since stations of the Calder Hall type generate a maximum steam temperature of only 400° C, the most efficient condensing conditions are required, for which vast quantities of cooling water are necessary. For a 400 MW station, approximately 35 million gallons are required every minute.

Such conditions stipulate either an estuary or shore site, or a lake; and, in each case, the intake has to be located far enough away from the outflow for the "new" cooling water, taking into account local currents, not to be warmed by that which has been discharged. For a coastal site, where sea-water is used as the coolant, it is desirable to locate the intake works beyond the five-fathom line.

In the area of the North-west, Merseyside and North Wales Region of the C.E.G.B., there is one major estuary and a longish coastline. There is not, however, an abundancy of potential nuclear sites. The estuary, apart from the shipping and consequent difficulties of siting and protecting the intake and discharge works, is a thickly populated area; it cannot therefore be considered. The Lancashire coastline, for



The north bank of the artificial lake at Trawsfynydd where the C.E.G.B. propose to site a 400 to 500 MW nuclear power station. The lake is a reservoir for an existing hydro-electric station.



If built, the station will feed the "current-deficient" area of Liverpool and Birkenhead, operating in conjunction with the Ffestiniog pumped-storage scheme. The site is located in the centre of the Snowdonia National Park.

A LAKE-SIDE IN THE WELSH HILLS

With the Ffestiniog Pumped-Storage Scheme it will Provide Power for Merseyside

the most part, is a very gently shelving beach, so placing the intake beyond the five-fathom contour involves an excessively long (and therefore expensive) conduit system. Along the north coast of Wales, in the region of Anglesey, the five-fathom contour approaches sufficiently close to the shore but the cliffs are relatively high. The rocks are of adequate strength to support the foundation loads with the station located close to the cliff face but either the condensing water would have to be pumped to the cliff top or the condensers would have to be sunk into the rock—adding even more to already heavy capital costs—and the condensate would have to be pumped. West of Bangor there is a coastal site which satisfies many of the requirements. But that is at a real beauty spot where any construction *would* desecrate the area.

Bearing in mind that the purpose of the station is to provide power for the Birkenhead-Liverpool area, it will be realised that sites any further west along the coast of the Caernarvon peninsula mean lengthening transmission lines until they are obviously uneconomic. Sites then have to be considered inland—the Cardigan Bay coast must necessarily be even more remote. A cursory survey shows that there is no river in the area which has anything like the flow to provide the cooling water required. A further search centres on the artificial lake at Trawsfynydd, formed some years ago when establishing the Maentwrog hydro-electric station. Indeed this is perhaps the only feasible site in the whole region. And even here special arrangements, such as training walls, will have to be made to ensure that the water circulates in the lake.

Trawsfynydd reservoir is roughly triangular in shape, 1¾ miles wide across the base and 2½ miles long. It is situated almost in the middle of the Snowdonia National Park, some 700 ft above sea level. The village of Ffestiniog is about 2½ miles from the nearest bank of the lake—the bank where it is proposed to site the station. The two aerial views on the opposite page give a fair impression of the actual site—a somewhat stony, desolate patch. It is not one of the finest areas in this region of beautiful and wild countryside, neither is it a vantage point frequented by walkers and climbers or holidaymakers generally.

At this point it is worth recording that the National Parks Commission do not object to the proposal—subject to certain safeguards being met. Such objections as have been lodged have been made by organisations which represent the interests of various groups of holidaymakers.

The National Parks Commission came into being as a result of the National Parks and Access to the Countryside Act of 1949. That act entrusts, for the most part, the planning of the Park areas to the existing local authorities. It enjoins the authorities—in the case of Snowdonia, the county councils of Merionethshire, Caernarvon and Denbigh—to preserve the ordinary activities whereby people earn their living; the Commission has also the task of maintaining a true balance between amenity and national needs, though its duties are mainly of an advisory nature. The county councils, faced with the C.E.G.B.'s proposals, had to consider whether the station would spoil their countryside and balance that loss, if any, against the advantages that could accrue to the nation in general or their locality in particular.

The councils have accepted the assurances of the Board that everything will be done to ensure that the station and its associated equipment will be well designed. To some extent a greater difficulty than the siting of the station was the routing of the heavy duty transmission line (275 kV) from the station to Connahs Quay and thence to Merseyside. This difficulty has already been settled in principle, if not in detail, in respect of the nearby Ffestiniog pumped-storage scheme, with which the power station will be linked and which is described later.

The three county councils had, however, another aspect of the problem to consider. Although among the most sparsely populated areas in the country they have nearly the highest figures (by percentage) for unemployment of insured adults. And so sustained has the period of low employment been that young people have been persistently leaving the area for the last 50 years, during which the population has halved. The advent of the station and of the pumped-storage scheme means work while construction is proceding—work well suited to men put off from the nearby slate quarries that have closed down. Later, when the station is operating, there will be employment for a new type of highly qualified and semi-skilled labour never before wanted in the area. Indeed, many responsible local people see the project re-establishing a community pride that has long been lost from the area.

The nuclear power station cannot be considered without some reference to the pumped-storage scheme under construction at Blaenau-Ffestiniog, having already received Parliamentary sanction. The scheme, to be the largest of its kind in Europe, will take electricity from the grid during the night period of low consumer demand and, in return, supply electricity to the grid at periods of high demand. The advantage of such a scheme is that, for a relatively low capital cost, it provides a peak-load capacity which would otherwise have to be obtained from less-efficient conventional thermal stations. From these considerations it will be seen that the pumped-storage scheme is not particularly dependent on the nuclear station. All that is required is a suitable site where the upper and lower reservoirs can be formed and a connection to the grid be made. The proximity of the nuclear power station—which is fundamentally a base-load project—has the merit of minimising the total length of high-voltage transmission line required to connect both with the area of heavy current demand—in this case, Merseyside.

At Ffestiniog the high-level storage will be formed by building a 90 ft high dam to increase the capacity of Lake Stwlan, 1,000 ft above the Afon Ystradau, which will be flooded by the lower storage reservoir.

The combined pumping/generating station will be equipped with four sets each comprising a motor-generator, a pump and a turbine. When excess current is available from 11 p.m. to 6 a.m. the motor-pump unit will raise water up to Lake Stwlan and for the 4 hours of peak demand each day the water will fall back to the lower reservoir through the turbines. Each electrical machine, to be built by British Thomson-Houston, is rated as a 104,000 b.h.p. motor and as a generator has a capacity of 75 MW. The pumps, which are to be made to a Sulzer design by English Electric, will be the biggest ever made in this country; English Electric are also making the Francis turbines which will operate under the highest head (1,000 ft) for such machines yet installed in this country. In each 24 hours 1½ million tons of water will flow up and down to produce 1,200 MWh, or 1¼ tons per kWh.

On the civil side the contract has been let to the Cementation Company of London. So far, only preliminary works have been started. The principal work will be the construction of the upper dam and some additional containing walls;

The Ffestiniog pumped-storage scheme: the land as it is and as a model shows it will be. The upper reservoir, Lake Stwlan, is about 1,000 ft above the artificial reservoir. The daily fluctuations in water level will be 18 ft on the lower and 65 ft on the upper reservoir.

The Human Element

PRACTICAL TRAINING FOR MECHANICAL ENGINEERS

The Institution of Mechanical Engineers have published Report on Practical Training, *which has been prepared at the request of the Council by a committee under the chairmanship of Mr. H. G. Conway. The Council invite comments on the recommendations, extracts from which are given below. Editorial comment appears on page* 481.

The committee are convinced that practical training in some form is essential for all those who aspire to become chartered mechanical engineers, whatever form of academic course is being followed. They strongly recommend that some practical training should be undertaken at as early an age as practicable.

Mechanical engineers, after completion of their training, are normally employed in one of the following principal activities: (i) manufacture; (ii) design (including development); (iii) commercial departments; (iv) operation and maintenance; (v) research. Although many mechanical engineers, as their careers develop, change from one activity to another, the committee are of the opinion that practical training should, at any rate in its later phases, bear some relationship to the type of work which the young engineer plans to do.

These considerations led the committee to recommend that practical training be divided into two stages:

I. *Basic Training.*—During this phase of training essential facts can be taught and certain basic experience acquired.

II. *Secondary Training.*—During this phase broader knowledge is acquired, insight is obtained into some of the workings of industry and human contacts are made at all levels. In the later part of this phase, training is related to the particular activity in which the individual will be employed when he has finished his training.

The committee stress the principle that theoretical and practical training should be co-ordinated to ensure that the total training period is treated as an integrated whole. The order in which the practical and theoretical elements are arranged is not uniform throughout the country. Some universities recommend candidates to proceed direct from school to university, deferring practical training until university studies for a first degree have been completed, though one or more vacation periods may be spent in industry. Others favour a sandwich course which includes six to twelve months of practical training between school and university, the balance being obtained after graduating. Still other colleges, especially those associated with the National Council for Technological Awards of Diplomas in Technology, prefer " works-based " sandwich schemes in which alternate periods of six months each are spent in industry and at college over a period of four or five years. All these schemes have certain merits.

The committee base their detailed recommendations on the following principles:

(i) Practical training must be firmly based on proper instruction coupled with actual experience of the processes being learned: planned " learning by doing " under skilled tuition, as opposed to vague experience based on chance.

(ii) Practical training schemes must be broadly based and yet they should also in their later stages take into account the type of work which the individual is to do when his training ends.

(iii) Opportunities must be provided for individuals who have not yet decided in which activity they wish to work on completion of their apprenticeship, to gain experience in various kinds of work during the early months of Secondary Training.

The committee look upon Basic Training as that part of practical training which everyone who aspires to become a mechanical engineer should undergo. [The report shows that Basic Training should last about 26 to 39 weeks, divided between bench work, centre lathe, milling, grinding, drilling, metrology, foundry, metal forming, and assembly; a detailed syllabus is given.]

In submitting proposals for this phase of practical training the committee adhere to a fundamental principle, namely, that it should be based on proper teaching by qualified instructors. There must be instruction in the principles underlying the tools or process being dealt with.

The instruction is best carried out in a training workshop, separate in organisation from the production workshops although under ideal conditions forming part of them. There are advantages in co-operation between several firms in a given district in the setting up of a training workshop in the factory of one of the firms, if each independently is not able to organise its own training school. It is also hoped that some technical colleges will provide workshops and may eventually be able to offer Basic Training.

[Drawings of typical components which the committee consider each individual should machine or make himself during the Basic stage of training are given in the report.] While it is not intended that these particular drawings must be used, any other examples chosen should follow similar lines.

Bearing in mind that Basic Training may have been carried out in a technical college, that is, away from a factory atmosphere, it is possible that many young men may still have little first-hand experience of the engineering industry. It is, therefore, essential for all, irrespective of the activity they will be engaged in at the end of their apprenticeship, to spend the early part of Secondary Training in engineering workshops and offices.

Those who have not yet decided upon their future careers should be given an opportunity to do so during the early period of Secondary Training. One way is by means of talks by senior executives who can describe the work of their departments and the qualities they are looking for in recruits. Until a decision about future career has been made, Secondary Training should not be specialised, but when his mind has been made up the man's chosen career ought to be taken into account in planning the remainder of the Secondary Training. [A chart included in the report shows that after Basic Training of, say, 6 to 9 months, there follows a period of about 6 months on the shop floor (less than this for the future research engineer), and then the remainder of the total of two years' apprenticeship is spent in shops, offices or laboratories according to which of the five activities the apprentice has chosen.] The chart also shows that the committee recommend that all mechanical engineering apprentices, except those definitely destined for a career in research, should spend at least six months on the factory floor. For men who are to follow a career in manufacture this period on the factory floor should not be less than nine months.

Mechanical engineers are employed in a very wide variety of industries and other vital fields, and in various functions within these activities. For this reason training programmes must themselves vary, and there is no rigid pattern of training which can be universally applied. The science of mechanical engineering is in any case a continuously developing one, and its applications are always increasing. It follows that there is room for experiment and new ideas in working out schemes of practical training. The committee desire to encourage a dynamic attitude to the subject, and hope to receive suggestions.

Continuing For Nuclear Power

the sinking of two vertical shafts 14 ft 6 in diameter, 700 ft deep, and then driving four 9 ft 6 in tunnels some 3,750 ft long to the penstocks; building the power station house; and building a 40 ft high dam, some 1,800 ft long, required for the lower reservoir. The shafts and tunnels are to be driven through the rock, partly for appearance's sake to save the face of the hillside being scarred by long large-diameter pipes and partly to avoid the somewhat irregular course that would result if the pipes were laid on the surface. The daily fluctuation in water level will be 65 ft on Lake Stwlan and 18 ft on the lower reservoir —which may cause a somewhat unsavoury condition at periods of low water in either reservoir.

The consulting engineers for the pumped-storage scheme, particularly the civil work, are Freeman, Fox and Partners; the responsibility for the electrical-mechanical equipment is in the hands of Kennedy and Donkin. The first two units are expected to come into operation during 1961, the third and fourth units in 1962. If permission for the nuclear power station is granted, the work will be offered for contract to the nuclear engineering consortia; the station could conceivably be commissioned by about 1963 or 1964.

Lake Stwlan, which will become the upper reservoir for the Ffestiniog pumped-storage scheme. The dam, with the mouth of the water shaft, will be in the foreground.

Continuing **The Human Element**

Religion on the Shop Floor

The possibility of setting up a body of ordained ministers trained and organised to operate in industry is put forward by the British Council of Churches in a new pamphlet entitled *The Church and Industry*. The Council are concerned not only with the problem of reaching the people, but with the lack of understanding which exists within the churches of "the problems of the manual workers in highly industrialised areas." Very few of those offering themselves for ordination have been wage earners in industry. When such people do offer themselves, "it is important," argues the Council, "that those in authority should be willing to ordain them if they are suitable and after they have received relevant, but not necessarily the traditional, preparation; for they have an important contribution to make in the situation from which they have come."

The pamphlet discusses briefly the efforts which have been made in various countries to bridge the gap between the wage earner and his religion—such as the priest-worker movement in France; the Sheffield Industrial Mission, operating in the steel works; the Iona Community in Scotland, and others. The pamphlet does not say that to have ordained ministers working side by side with wage earners is the solution. To some extent they appear to share the view of the Catholic hierarchy that a priest cannot work in a factory—taking part in the social activities of wage earners, including trade union work—and at the same time fulfil his duties of priest.

The Council of Churches are feeling their way into this most difficult subject. The need for clearer understanding of the problems involved is undeniable, and urgent. Theological students should doubtless be given better training and instruction. But above all the leaders of the Church require to define the problem by the use of well-tried social research techniques. The solution might well be a new approach through the home—increasingly people stay at home on Sunday to watch television—or through advertising, or in new techniques of public address. At present the lack of knowledge is the major handicap.

Bread and Butter—and Chalk

Basic salary scales were the main topic of discussion at the annual conference of the National Union of Teachers in Scarborough last week. There was overwhelming support for the executive's recommendation that the union should negotiate for a basic salary scale "of the order of £600 to £1,200." The supporters of a higher scale found little enthusiasm for their claim that it should be one of £700 to £1,400, and their amendment was heavily defeated.

The executive have been left some room to manoeuvre. They rejected one amendment calling for a basic scale of "not less than" £600 to £1,200 and many others fixing specific amounts and time for increments. Mr. J. V. A. Long, chairman of the salaries committee, explained that they had arrived at the recommended figures by translating 1938 values into 1958 values "with a small betterment factor." The increases, if granted, would cost approximately £58 million or 27 per cent more than their present salaries bill of £213 million a year. But the executive will also ask for a substantial shortening of the scale so that graduates, trained teachers and teachers with special qualifications should get higher allowances.

The delegates' concern over working conditions emerged dramatically when an amendment to a motion instructing the executive to "take immediate steps to ensure that teachers be entirely relieved of all duties relating to school meals" was defeated. A resolution that school meals and medical inspection of children should not be included in the Educational Vote was passed unanimously. The enthusiastic backing of a call for an invitation to be sent to women teachers for the annual conference in Cardiff completes the setting of the stage for the forthcoming discussions with the Government.

Negotiations off the Rails

Not all the immediate consequences of the findings of the railway tribunal on wages have yet been worked out and some more are likely to develop after this issue has gone to press. Nevertheless, it is apparent that two basic issues have now come to the fore in labour-management relations and will have to be dealt with. They were already apparent in the dispute over busmen's wages. They have been underlined by the railway crisis.

The two points are these. First, the issue has to be faced as to whether workers are to be paid with some regard to financial book-keeping (the standard is hardly yet solvency for the British Transport Commission is already heavily subsidised by the taxpayer) or whether pay demands are to be allowed to drive a key industry into a permanent condition of not making ends meet. Part of this question is whether workers should always have pay rises to offset increases in the cost of living. The railway tribunal has said they should not.

The second point is the future of arbitration. As Sir Godfrey Ince has said twice recently, the value of arbitration is that its results are in a sense morally binding. There are no sanctions to force its conclusions on either party and it provides an important means of saving face. If British industry will not accept the moral sanction, it puts arbitration into disrepute—and there is nothing beyond it except industrial warfare.

Outlook for the Builders

A second approach is to be made by the building unions to the employers for agreement to a 3*d*. an hour increase in wages. Since the claim is not likely to get a better reception than it did the first time, the issue is likely to go to arbitration. The decision last week to persist with negotiations was unanimous, but there was no sign of a concerted demand for militant action. It is likely that the existence of some 50,000 unemployed in the industry has had a cooling effect on tempers.

The position of the building industry is not very good a the present. The volume of plans passed for building construction work of all kinds remains at a low level and the position would be even worse were it not for the large amount of work still to be done for the nationalised industries. Housing for the time being is in a poor way. The unions are thus pressing a wage claim at about the worst moment so far as the trade cycle is concerned, though it is quite possible that the outlook for the industry might suddenly change for the better. There have been official hints that if the Government were to take remedial action to avoid further deflation they would begin by giving more work to the building industry. That being so this particular industry may not have far to go before the outlook improves. With that would come an improvement in the chances of the workers getting more pay, and going to arbitration may therefore be the best thing to do. It will not look very spectacular to do so without brave words as well, but it may be good timing.

Flirtation as a Policy

The Easter delegate conference of the Union of Shop, Distributive and Allied Workers was notable for the speech by Mr. Birch on the terms on which the unions ought to accept wage restraint. He did not use the words "wage restraint" since they have become somewhat dirty in union circles but his circumlocution amounted to the same thing. His views were of added interest since he is chairman of the Trade Union Congress economic committee.

He said that the unions should not accept any restraint which was claimed to be necessary to carry out national economic policies which are wrong (by which he meant unpopular with the doctrinaire element in the unions). If the cost of living went up because of these policies, labour should have its real wages kept intact. The unions should favour the party which believed in handling inflation by controls. It was an easy step from this to saying that the unions should co-operate with the Labour Party in economic policy.

These blunt hints that the unions will co-operate with Labour but not with another party are double-edged. They increase public suspicion that the unions are a fourth estate of the realm and they open the way for violent disagreement among the big unions as to who may commit whom to what. They are a little ingenuous, too, for they commit the unions to support of a policy and a political party to nothing. The latter can always plead *force majeure*.

Rings for Upper Yardmen

While the Navy continues to reduce its shore-based establishments as a measure of economy and adjustment to the technical changes of the atomic and guided missile age, it has constructive changes of another kind in view. The Admiralty have announced that revised plans for entry and training under the Upper Yardmen scheme for the promotion of ratings to commissioned rank are to be brought into effect.

The term Upper Yardmen dates from the sailing days when the best youngsters were sent into the upper yards of the ship. Under the new scheme successful candidates for commissioned rank will serve a preliminary 28 weeks as cadets at H.M.S. Temeraire (where Upper Yardmen at present do all their training for commissioned rank, passing out as acting sub-lieutenants). They will then go on as midshipmen to Dartmouth where they will join the normal cadet entry. The seniority of officers appointed under the Upper Yardmen scheme is being adjusted to minimise the age gap between them and cadet-entry officers. Apart from the initial stages, from now on there will thus be only one channel of training for commissioned rank in the Navy.

The Glitter of the U.S.

Some 60,000 "professional, technical and kindred workers" entered the United States for permanent residence in the four years July 1952 to June 1956. The largest single source was Canada, which had a total for the period of nearly 16,000, but European countries supplied 26,000, or 40 per cent of the total. Germany and the United Kingdom were the main contributors, with 6,890 and 6,406 respectively.

Professional immigrants accounted for just over 6 per cent of the total immigration of 900,000 over these four years. They went not so much because they were wanted, as because they wanted to go: only 7 per cent entered the country with a first-preference quota visa, authorised to persons of specialised skills whose services are urgently needed in the United States. The analysis of the 60,000 entrants showed that although engineers, physicists and chemists accounted for about one-fifth of the total, the teaching, legal and medical professions supplied about as many and that 8,226 came in as nurses. Inevitably, it would seem, the attraction of the United States is greatest to those in Europe and elsewhere who are relatively poorly paid and work under unsatisfactory conditions.

Atomic Review

The Material Question

It is not often that we hear of heckling during speeches by the Russian Prime Minister. Like all astute orators, Mr. Kruschev has, it would seem, developed methods for forestalling spontaneous criticism. However, on the rare occasions that interjections are made, whether they be during the course of a disquisition on the status of certain great nations, or at the end of a brief panegyric on Tokay wine, it is satisfying to note that the comments are not wholly facetious and that, in many cases, they have a commendable relevance and succinctity.

" We have everything. We have 200 million men with strong arms. Our strength is enormous," said Mr. Kruschev, when visiting a collective farm in Hungary. He elaborated his theme, going on to explain that Russia had everything she needed, in her own territory. But this was too much. " What about uranium ore? " inquired a voice from the collective.

Unfortunately no answer has been reported. And although Hungary is known to supply appreciable quantities of the ore to Russia, no figures appear to exist concerning what proportion of Russia's total supplies of raw nuclear material these supplies constitute. Figures for other parts of the world are known, however, and these are summarised below.

Uranium Production in the United States

The United States Atomic Energy Commission's uranium production programme, which was initiated less than ten years ago, moved slowly at first but rapidly gained momentum. Production has risen greatly during the past four years but a major increase will come in the next twelve to eighteen months with the completion and operation of a number of large Canadian and American uranium mining and milling projects. The free-world production in 1957 was expected to have been 21,000 tons of U_3O_8 and the estimate for 1959 is in excess of 40,000 tons, with more than 30,000 tons coming from the United States and Canada.

Speaking before the fourth annual conference of the Atomic Industrial Forum, held in New York last autumn, Mr. J. C. Johnson, director of the raw materials division of the Commission, said that ten years ago the United States were dependent upon the Belgian Congo for more than 90 per cent of their uranium. Production in Canada and the United States was insignificant by present standards and known ore reserves were equally meagre. At that time the only possibility of large additional production from any known source was the recovery of uranium from South African gold tailings. Here the problem was to develop a process to recover economically less than 1 lb of uranium oxide per ton of material treated. Except for the South African gold ores, any major increase in uranium production had to come from new discoveries, unless the authorities were prepared to pay from 30 to 50 dols. a lb for uranium from low-grade phosphate and shale deposits.

Answers were found to the metallurgical problems involved in processing South African gold-ore tailings. Mill construction began early in 1951 making this the United States first major new uranium production project. The South African gold-mining industry deserves great credit for the speed with which the large engineering and construction programme was carried out and for the efficiency of the milling operations. South Africa now is producing approximately 6,000 tons of U_3O_8 per annum.

South African production, however, was insufficient. New sources of uranium had to be found and brought into production. The instructions were to get as much uranium as possible from every available source, but production from the North American continent was particularly important for obvious strategic reasons.

Consequently, the programme of 1948 to stimulate exploration concentrated on the United States and Canada. There were no specific reasons for great optimism except that there was a vast mineral-bearing territory in which to search. Any chance for even a measure of success in a short time depended upon enthusiastic participation by hundreds, if not thousands, of prospectors, geologists and mining organisations.

One of the surprises of the past few years has been the size of the United States sedimentary-type deposits and the extent of the ore reserves developed in areas having no significant surface exposures. The Big Indian Wash district in Utah, and the Ambrosia Lake field of New Mexico are examples of major discoveries by drilling. The outcrops in the Gas Hills district, Wyoming, provided little indication of an important uranium area. On account of the widespread exposure by erosion of the sedimentary beds in which the uranium is found, it was expected that surface outcrops would give better indication of the size and extent of the uranium resources.

The home ore reserves of the United States are now estimated at about 70,000,000 tons averaging about 5 lb of uranium oxide per ton. A year ago these ore reserves were 60,000,000 tons; two years ago, 25,000,000 tons; three years ago, 10,000,000 tons and four years ago, 5,000,000 tons.

Most of these ore reserves are in deposits ranging from several hundred thousand to several million tons. Earlier, most of the deposits were less than 100,000 tons. Small mining operations still provide a substantial part of the uranium production but with the discovery of larger deposits the trend has been toward more considerable mining operations, both underground and opencast.

Uranium Production Outside the United States

It appears that 17 uranium plants are now at work in connection with South African gold mining companies and news has also reached us that the United Kingdom Atomic Energy Authority has declared its intention to purchase annually from mines in British East African territories and also from British Guiana concentrates containing up to 500 short tons of uranium oxide.

Canada is the largest producer of uranium ore after the United States and last year exported nearly 6,700 tons of uranium oxide, mainly to the United States but also to the United Kingdom, Japan and Western Germany. Rich new finds of the mineral have been reported from Labrador. As the result of prospecting on the shores of Kaipokok Bay, which is situated some 125 miles north-east of Goose Bay, what is characterised as an exceptionally rich orefield has been discovered by British Newfoundland Exploration Limited, a British company. As a beginning it is proposed to produce 200 tons of high-grade milled ore a day.

Prospecting for uranium ores continues in various European countries and a stratum of the mineral is stated to have been discovered in the Dordogne, Central France. No figures have been given to us but the stratum is stated to be the richest ever discovered in France. In Italy small bodies of uranium ore have been located in the Maritime Alps and it is stated that 65 tons of uranium should be produced in 1960, 130 tons in 1961 and 350 tons in 1962. It is calculated that this last figure would be about 30 per cent of the total metal required to supply the nuclear power stations built by that time.

It is claimed that Russian technicians have devised a process for the extraction, by chemical means, using organic catalysts, of uranium from sea-water. There is only $\frac{1}{2}$ oz of uranium in 1 million gallons of sea-water, hence the process presents many difficulties. It is stated, however, that operations on water taken from the Pacific Ocean have been successful.

Uranium ores require careful handling. These workers grinding the ore are safeguarded by masks that prevent inhalation of radioactive dust.

Present and Future Supplies of Thorium

Increasing numbers of countries are now prohibiting the export of thorium, the material employed as an alternative to uranium as the atomic fuel for nuclear power production. Thus, Australia and India have placed a strict embargo on export sales of thorium, while Brazil is exercising stringent control over her markets. These three countries, namely, Australia, India and Brazil, together with Russia and Ceylon, possess the most considerable known deposits of monazite sands, rich in thorium. Ores of thorium, however, also occur in West Africa and in Asia, in Korea, Sumatra and Borneo, and thorium deposits are found, moreover, in the United States and Canada. Hence it is still possible to obtain supplies although perhaps from unfamiliar sources.

The reason for the prohibition of exports is given in the current fifth annual report of the Australian Atomic Energy Commission. This states categorically that while prospecting and development work in future years should continue to uncover new reserves of uranium, " the possibilities of finding more thorium are

strictly limited." In view of this opinion it is quite understandable that the authorities in Australia wish to conserve the available supplies of thorium for future Australian needs. No doubt a similar argument is advanced regarding Indian and possibly Brazilian thorium.

The fact, therefore, that supplies of thorium have been found in commercially-attractive quantity by technicians of the Geological Survey of Nyasaland, working in collaboration with geologists of the United Kingdom Atomic Energy Authority, is a matter of interest in this country. The thorium occurs in deposits of radioactive sands found near Monkey Bay on the southern shore of Lake Nyasa.

Separation of Unused Uranium and Plutonium

A problem which has been of prime importance since the advent of atomic energy is that involving the separation of unused uranium and plutonium from spent reactor fuels. The recovery of uranium fuels has been achieved by using a solvent such as tributyl phosphate to extract uranium and plutonium nitrates from a solution obtained by dissolving the reactor fuel rods in nitric acid. Solvent extraction processes of this type have been widely employed in recent years for purifying materials for many industrial applications.

New reactors are now being developed and these will utilise new fuels such as uranium alloy and plutonium. To deal with these new fuels, the solvent-extraction processing methods employed at present will have to be extended and this work is being undertaken at the Dounreay research and development chemistry laboratories.

The investigation will demand very special techniques and a high degree of skill. All the work will be done in glove boxes and it may involve also active materials requiring remote handling.

Recovery of Spent Nuclear Fuels in United States

That the problem of recovering uranium and plutonium cheaply is also exercising the minds of atomic chemists in the United States is evidenced by a statement made in New York recently at a symposium on "Reactor Fuel Reprocessing" by Mr. C. G. Manly of the United States Atomic Energy Commission. He suggested that small, compact, or "packaged," re-processing plants designed to recover not only uranium and plutonium but also radioisotopes might be the best way of solving the problem of low-cost processing in present-day conditions. Mr. Manly went on to state that each packaged plant would be designed to re-process the reactor fuel used by one reactor owner which could be situated at the reactor site. No really firm statement on the economics of such plants could be made on account of the lack of data on the best chemical processes to be used, on the precise value of the market for fission products, and on the techniques of the storage of waste solutions. The construction of small processing plants, however, might be attractive as an initial step.

There might be significant cost advantages for a processing plant on the same site as a large reactor, when comparisons were made with an installation on a separate site. Some of these advantages might include the sharing of staffs, services, overheads, laboratories, and maintenance shops, and, in some areas, making common use of a crane, canal or a ventilating plant. To sum up, a reactor owner would own a re-processing plant in much the same way as consumers of fuels carried out their own ash-handling operations.

Whether the processing of spent nuclear fuels could be conducted profitably in some such manner as that suggested, however, really depended upon the ingenuity brought to bear on the subject by chemical-plant designers.

Storing Plutonium in Safety

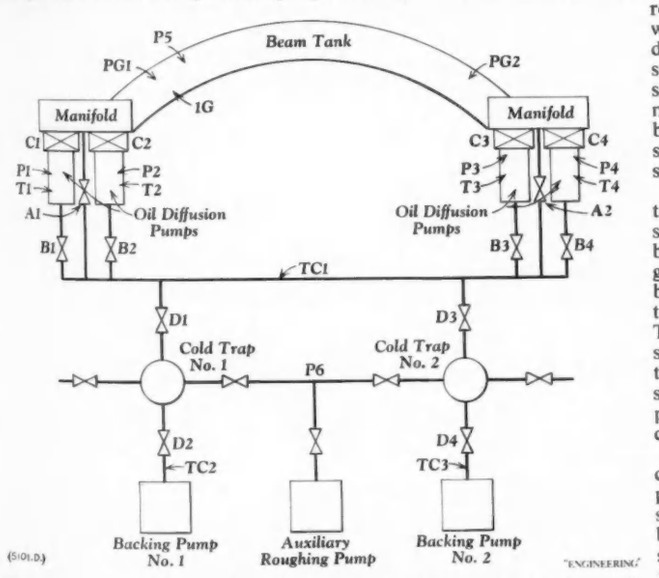
The safety factors involved in the storage of plutonium are discussed in A.E.R.E. publication T/M 63, by Mrs. M. B. Biram and Mr. K. T. Spinney.

The authors state that the problem placed before them consisted in examining the safety of a method of storing plutonium rods prior to their assembly into a fast fission reactor. The amount of the material to be stored totalled about 20 kg and it took the form of rods 6 in in length and each weighing 60 g. It was proposed to store numbers of these rods in holes drilled into solid iron cylindrical blocks called sub-containers. Each sub-container, of which there were 48, was itself fitted into holes sunk into iron cubes of 1 ft side. The 48 cubes were then stacked, side by side, into four recesses let into the concrete walls of a corridor in the basement of the reactor building. The sub-containers were units in which the plutonium was moved about the building and a system of interlocking doors ensured that only one was removed from the recesses at a time.

Most sub-containers took seven plutonium rods and confirmation was needed that this distribution was quite safe. It was also necessary to ascertain how many more rods could be safely stored in each sub-container, if this should prove necessary.

The effects of concentrating plutonium into separate containers had been investigated, together with the possibility of interaction between such containers. The possibility of the slowing down and reflection of neutrons in the surroundings of the store place had also been considered.

As a result of the calculations made, the proposed method of storing plutonium had been shown to be quite safe for as many as 17 plutonium rods per sub-container.



Vacuum system of heavy-element electromagnetic separator ("Hermes")

A1 and A2.	Pneumatically-operated 1½ in valves.	IG.	Cathode ionisation gauge.
B1 to B4.	Pneumatically-operated 1½ in valves.	P1 to P6.	Pirani gauges.
C1 to C4.	Main isolation valves.	PG1 and PG2.	Penning gauges.
D1 to D4.	Pneumatically-operated 1½ in valves.	T1 to T4.	Temperature-operated relays.
		TC1.	Thermocouple gauge.
		TC2 and TC3.	For measuring pressures over two main backing pumps.

Vacuum Techniques and "Hermes"

In the latest issue of *Vacuum* (vol. 5), published by Edwards High Vacuum Limited, there is an article, "Vacuum Technique in Atomic Energy Research," by Mr. A. H. Turnbull of the Atomic Energy Research Establishment, Harwell. The purposes for which vacuum equipment and techniques are used at A.E.R.E. are described. Reference is made to metallurgical applications, measurements of the gas content of metals, the production of thin films, vacuum technique in mass spectrometry and high-power radio-frequency valve manufacture. The article comments on the vacuum systems for the new proton linear accelerator and the Mark II heavy-element electromagnetic separator, known as "Hermes".

Although the vacuum system of the Mark II heavy-element separator ("Hermes") is comparatively small (for example with respect to that of the new proton linear accelerator at Harwell), it is worthy of description on account of the control devices which render the vacuum operations almost fully automatic. The high vacuum side of the system consists chiefly of the "beam tank" through which the positive ions pass from the source at one end to the collector at the other. This tank has a volume of 12·5 cu. ft and the pressure in it has to be maintained at not more than 2 by 10^{-6} mm mercury under operating conditions. At each end of the beam tank is a manifold into which are built two liquid nitrogen-cooled traps. Each trap communicates through a 12 in isolation valve with a 9 in oil diffusion pump. These main isolation valves are pneumatically operated, the air supply being controlled electrically by solenoid valves on a remote control panel.

Zirconium Production

It is stated in the article referred to above that zirconium—a metal used in fuel element cans can be prepared by vacuum sublimation of zirconium fluoride ZrF_4, thus removing oxides and impurities such as iron, nickel and copper. The fluoride is placed in a stainless-steel tube lined with nickel, which is heated to 700° C. The zirconium sublimates and is condensed on an air-cooled surface at 300° C.

Notes and News

Bradwell Heat Exchangers

Construction of the first of twelve heat exchangers for the Bradwell Nuclear Power Station is nearing completion at the Thornaby Works of Head Wrightson and Company, Limited.

These heat exchangers, fabricated in 1 $\frac{9}{16}$ in thick steel plate, are 95 ft long, 20 ft in diameter and weigh over 200 tons. When the first heat exchanger is completed in May of this year it will be launched into the river Tees from Head Wrightson's slipway and towed round the coast to Bradwell, on the Blackwater Estuary in Essex. On arrival the exchanger will be landed and lifted on to its foundations by the Goliath crane.

Harwell Reactor School Course

The United Kingdom Atomic Energy Authority have announced that the next Reactor School Course, for which places are available, will commence on 1 September 1958 and finish on 23 December 1958. It has been arranged that the first six weeks of the course will be held at Birmingham, Bradford and Salford Colleges of Advanced Technology and the remaining part, from 15 October, will be held at the Harwell Reactor School. The fee for the course, which is open to British and overseas students, is £250.

Application forms and further details may be obtained from The Principal, Harwell Reactor School, Atomic Research Establishment, Harwell, Berkshire, England.

Undergraduate Course

Southampton University now provide a course in nuclear engineering for first-degree students. Some aspects of the course are discussed on p. 483 in a letter to the editor from Dr. N. S. Grassam, the lecturer in charge of the course.

Companies in the News

Demands of Expansion

In his annual statement published last week Lord Chandos, chairman of Associated Electrical Industries Limited, dealt with the reorganisation of the company. The first stage, which involved the formation of four groups—B.T.H. (with the A.E.I. Lamp and Lighting Company, Birlec and Hill Top Foundry), M.-V. (with Ferguson Pailin and Sunvic), Siemens Edison Swan and the Overseas Group, has been completed, and the groups are "working smoothly and satisfactorily." The second stage, towards a change to a divisional organisation based on products, has just begun. Initially two A.E.I. divisions are being formed. The Turbine-Generator Division, which will be managed by M.-V., and the Heavy Plant Division under B.T.H. These divisions will control the design, manufacture and sales of all products within these categories.

Lord Chandos defined the ideal at which he and his colleagues are aiming as "a devolution of executive functions to subsidiary boards while maintaining a strong central control of industrial and financial policy." He emphasised the constant need to adapt organisation to changing conditions and explained that the further reorganisation now begun was made necessary by "the increasing size of our business, our hopes that it may double in ten years and changes in the nature of the market for electrical apparatus." The divisional organisation is designed to eliminate duplication of effort and to make the best use of personnel.

The order position of A.E.I. has improved considerably following a large influx of orders at the beginning of last year which has continued. The last to be announced is for the supply and construction of seven 132,000 volt substations in the Buenos Aires city area. The order, approaching £5 million in value, is the largest ever booked by A.E.I. for this type of equipment. Orders taken during 1957 totalled £177 million, over one-quarter more than the previous highest figure reached in 1956. The fact, announced for the first time by Lord Chandos, that only 10 per cent of the total business is in consumer goods, suggests that there exists an underlying demand of great strength for electrical plant and machinery throughout the world. Another fact, also news, that A.E.I. have supplied 43 per cent of the major generating plant commissioned by the C.E.A. during 1957 is another indication of their strength.

Vote of No Confidence

Mr. Herbert E. Hill, chairman of Birfields, has produced an unusual annual statement this year—unusual but striking and one which expresses the feelings of many business leaders in his position. In his remarks on his group's outlook he said ". . . no-one surveying the scene in our country can permit himself any sense of real confidence. There is a serious *malaise* aggravated by twelve years of poor Government. The causes of the deterioration of character and attitude over this period have been many and some excuses can be made. The undeniable fact is that it cannot continue."

Mr. Hill is an accountant of standing, with some considerable achievements to his credit in the field of industrial organisation and management. The broadening of his group's activities, and the additional penetrating power derived from the reorganisation on new centralised lines, are evidence of this. He feels, along with many others in industry, that there is a lack of drive and a softening of character which has come about through the easy living of the post-war years. There is no suggestion in his admonition that it is directed principally at the trade unions: all levels of management are implicated. What Mr. Hill has said so bluntly about "our former character and reputation" and "our own feebleness and folly" is tantamount to saying that we no longer know how to work in competitive conditions. Nevertheless, the achievements of some firms—here Marks and Spencer spring to mind, also English Electric, Ford and several others—suggest that the key to success lies in a management team unwilling to be complacent.

Birfield have continued to expand. The new factory for Hardy Spicer will be completed before the end of this year. The existing Witton factories of that company will be occupied by Salisbury Transmissions, who are expanding rapidly. A new factory has been completed for Intermit; the Phosphor Bronze Company's factory in Birmingham has been rebuilt and several other new factories have been or are being completed. The decision to set up development and engineering units within the group will lessen their dependence on licensing agreements with foreign manufacturers. As the chairman put it, Birfield will now be less exposed "to risks arising from the inefficiency and failure of others."

South Africa's Bright Promise

South Africa has become a country of extremes, both political and economic. It is also a country of fantastic achievements by individuals in industry. A seasoned old campaigner, chairman of many companies, was once heard to remark to the son of a friend: "Go to Jo'burg, my boy, nowhere else could you do better." There are certainly few places where success in business is so fully rewarded and where management ability counts for so much. At present, South Africa is feeling the economic draught only slightly. Sir George Usher, who emigrated there a few years ago to take over International Combustion's South African subsidiary, told his shareholders that trading conditions "were becoming more difficult," but not in a way which made him apprehensive of the future. He expressed full confidence in the continued economic growth of the country and foresaw bright prospects for International Combustion Africa Limited, who have recently obtained new large contracts and have a well filled order book.

One of the most promising features of South African development is the ability of its industry to produce at low cost. In the recently published annual report of the Messina (Transvaal) Development Company Limited, their chairman, Commander H. F. P. Grenfell, told shareholders that despite the low level of copper prices the company had been able to continue "operating at a profit—moderate though this may be" with copper at £160 a ton. He attributed this to measures taken in recent years to improve efficiency which have involved considerable capital expenditure. In view of the very serious difficulties of United States and Chilean producers, this suggests that the South African industry is in a very strong competitive position.

Trading prospects in the Union were discussed by Mr. Roland Paget, chairman of Hubert Davies and Company Limited, who are metal and engineering merchants and manufacturers with branches in most industrial centres. Hubert Davies ended their year (to 31 October, 1957) with a reduced profit but are continuing to expand. Mr. Paget's closing remark "that there is a bright future for this country, and the Federation" seems to be fully justified even in these uncertain times.

In Parliament

RADIOACTIVE MATERIALS

Just prior to the adjournment for the Easter recess, Mr. Harold Macmillan, the Prime Minister, told the House of Commons that the United Kingdom Atomic Energy Authority transported radioactive loads by road between Windscale and their other establishments. The routes were chosen to avoid congested areas as far as possible and were agreed beforehand with the Ministry of Transport and Civil Aviation.

Radioactive loads had never been taken by lorry through the middle of Manchester or Salford, though it had sometimes been necessary to take them through the outskirts of those places. Every care was exercised, both in the design of containers and in the method of loading, to ensure that if a serious traffic accident did occur, there would be no release of radioactivity. Each consignment was accompanied by an escorting official in a separate vehicle.

The methods which would be used to transport radioactive materials between Windscale and the atomic power stations now under construction, were being discussed by the Authority and the Central Electricity Generating Board. He was satisfied that they would observe the same high standard of safety precautions as the Authority did at the present time in the conveyance of their own radioactive materials.

ARTS STILL LEADING

The Chancellor of the Exchequer was asked by Mr. Arthur Skeffington (Labour) how the estimated university population of 124,000 in 1965 would be proportioned between the different faculties. Mr. Derick Heathcoat Amory replied that in October, 1957, university students were distributed among the different faculties in the following proportions: medicine, dentistry, veterinary science and agriculture, 20 per cent; arts, including the social services, 43 per cent; and pure science and technology, 37 per cent. It was expected that about two-thirds of the increase in the total number of students would take up science and technology, or about one-third arts and other subjects. It was not possible to be more precise at this stage.

TECHNICAL STUDIES IN SCOTLAND

Asked by Mr. Malcolm MacPherson (Labour) to state his policy with respect to liberal studies in connection with advanced technical courses in Scotland, Mr. John Maclay, the Secretary of State for Scotland, said that he was assisting the efforts being made by the institutions concerned in Scotland to give effect to the views of the Government on this matter, as stated in paragraph 11 of the White Paper on *Technical Education* (H.M.S.O., Cmd. 9703, price 1*s.* 9*d.*). These efforts included the broadening of the treatment of technical and scientific subjects, the introduction of additional subjects, the development of library facilities, and the encouragement of extra-curricular facilities.

HELICOPTERS ON THE THAMES

Mr. Airey Neave, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, told the House that applications by two private firms for planning permission to provide helicopter landing facilities on the River Thames were to be heard at local inquiries held in public, in accordance with arrangements made by the Minister of Housing and Local Government. These applications, he told Lieut-Colonel Marcus Lipton (Labour), were for a site near York Road, Battersea, and for a floating pontoon adjoining the Albert Embankment, Lambeth.

Russian Scientific Journals

At the present time, the lending library unit of the Department of Scientific and Industrial Research receives regularly copies of translations of some 24 Russian scientific and technical journals. These translations, Mr. Harmar Nicholls, the Parliamentary Secretary to the Ministry of Works, told Mr. F. T. Willey (Labour) are available on loan to any organisation in the United Kingdom and a list is obtainable from the D.S.I.R. on request.

Research and Development

LLOYD'S SURVEY OF BRITTLE FRACTURE

Previous to the disquieting failures which occurred in American all-welded ships during and after the war, comparatively little was known about brittle fracture; it had never emerged as a serious factor in the safety of riveted ships. The American Board of Investigation, appointed to investigate the early welded ship failures, issued a comprehensive report in 1946; and the Admiralty Ship Welding Committee appointed in this country, issued reports between 1946 and 1953.

Broadly it was concluded that the fractures arose from the brittle behaviour of the steel in the presence of notches in the structure, either geometric notches or faults in welds, and that brittle fractures from such notches were liable to propagate catastrophically through the continuous envelope of a welded ship under normal conditions of weather and temperature. It was also realised that conventional factors of safety, based on the ultimate tensile properties of the steel as usually measured, did not cover this type of failure.

Recommendations made as a result were mainly directed to minimising all forms of notch effects and to improving the toughness of the steel. The measures taken on existing ships took the form of improving hatch corner arrangements, rounding off other square corners, and fitting longitudinal riveted crack arresters. Improvements in the notch toughness of steel have resulted from amended steel specifications; briefly, these amounted to specifying a minimum manganese/carbon ratio of 2·5 or otherwise controlling these constituents for plates exceeding ½ in in thickness, and requiring steels made to specially approved specifications for plates over about 1 in thick when used for the main structure.

While the incidence of failures during the last few years has shown that these measures have appreciably reduced the risk of major failure, the number and extent of brittle fractures in post-war welded or partly-welded ships, in which some of the recommended improvements existed, could not be regarded as entirely satisfactory. Between 1951 and 1953 two comparatively new all-welded cargo ships and a transversely framed welded tanker broke in two, and in the winter of 1954 a longitudinally framed welded tanker, in which up-to-date design and welding quality as well as improved steel had been embodied, also broke in two. In addition, some all-welded oil storage tanks have completely failed.

As a consequence, the Admiralty Ship Welding Committee was reconstituted in 1954 as the Admiralty Advisory Committee on Structural Steel " to make such recommendations as may be practicable or desirable regarding the quality and testing of structural steels with special reference to brittle failure and suitability for welded construction." It issued its first Interim Report in 1957. In the United States, the Ship Structure Committee has continued the long-term fundamental investigations recommended by the original Board of Investigation, and important researches have been carried out in other countries.

In the meantime, those taking responsibility for structural safety have been obliged to decide on what further preventive measures are necessary. Lloyd's Register has for many years systematically recorded casualties and investigated cases of brittle fracture, and, on 25, March at a meeting of the Institution of Naval Architects, Mr. J. Hodgson and Mr. G. M. Boyd, respectively a former member and a member of the staff of the Society, presented a paper entitled " Brittle Fracture in Welded Ships: an Empirical Approach from Recent Experience." The investigations dealt with in this paper relate mainly to fractures in ships built since 1945 and do not include American wartime ships. Casualty investigations show, in the majority of cases, that failure cannot be ascribed solely to one particular cause, but it is sometimes possible to deduce the most significant factors which, in combination, have led to failure.

Table I shows an analysis of the incidence of fractures in the main structure sustained in service by 182 modern cargo ships and tankers of both riveted and welded construction. Some of the " riveted " ships were partly welded and vice-versa, but the decision in each case has been made on the basis of the structure in the vicinity of the fracture. On a comparable basis of total ship-months service, the number of fractures in these welded ships is about 18 per cent more than in the riveted ships, but welded tankers are about 28 per cent more susceptible than riveted tankers, while the corresponding figure for dry cargo ships is 10 per cent.

TABLE I.—*Incidence of Fractures in Riveted and Welded Ships*

	Riveted			Welded			
	Tankers	Dry cargo	Total	Tankers	Dry cargo	Total	
No. of ships examined	33	54	87	45	50	95	182
Average age, years	8·95	7·95	8·31	7·25	8·65	7·99	8·15
Total months of service	3,542	5,148	8,690	3,915	5,188	9,103	17,793
Total number of fractures ..	98	140	238	139	156	295	533
Fractures per 100 ship months ..	2·76	2·72	2·74	3·55	3·01	3·24	3·00
Percentages welded over riveted ..				28 per cent	10 per cent	18 per cent	

NOTES:
1. The table is confined to shelter deck dry cargo ships between 250 and 470 ft long and single deck oil tankers between 400 and 600 ft long, built between 1945 and 1956 inclusive, excluding ships built in U.S.A.
2. Only fractures in the strength deck and shell reported up till December, 1956, inclusive, are considered. Fractures in the internal structure and forward panting and slamming areas are excluded. Fractures during construction are also excluded.
3. The total months of service include time in port.
4. The table takes no account of the severity or extent of the fractures.

There is a strong tendency for fractures in welded ships to be more extensive than those in the riveted ships. The reason is by no means clear, since comparatively few of the fractures in the riveted ships have been reported as stopping at riveted seams; but while in the riveted ships the fractures tend to be confined to obvious points of stress concentration, such as square hatchway corners, those in the welded ships are more widespread. The number of fractures in decks is considerably less in tankers than in dry cargo ships, due no doubt to the influence of large rectangular openings in dry cargo ships.

All the dry cargo ships considered were transversely framed. Cargo ships so framed, particularly when welded, are inherently liable to slight corrugation in the bottom plating, due to the maximum stresses being predominantly hogging; but experiment has shown that the effect on the strength of the hull girder as a whole is not significant for the degrees of corrugation found and accepted in practice, and does not greatly affect the tensile stresses at the deck. In no case was there any indication of further buckling in the bottom as a prelude to fracture at the deck. It can be concluded that this factor had little or no significance in the casualties investigated.

All the tankers considered were longitudinally framed, at least at the bottom and deck, except for one which was transversely framed and all-welded, and which broke in two; but it may be said that, following earlier experience with this type of tanker, the structural arrangement provided against secondary buckling of the deck plating were effective, and the case was one of failure primarily by brittle fracture.

From a general consideration of the pattern of fractures in modern welded and riveted ships, there can be no doubt that the risk of serious fracture is greater in the welded ships, and this must be due to factors inherent in welded construction. Some major structural failures have occurred to wholly riveted ships, but there have been few, if any, known cases of total failure traceable to " spontaneous " fracture of the kind experienced in welded ships. Two cases frequently quoted are the similar transversely framed all-riveted tankers Janko and Osthav, which broke in two during very heavy weather in 1951; but investigation showed that the structural arrangements at the deck were inadequate to withstand high compression, and that the initial and primary cause of failure was buckling of the deck plating between beams under the prevailing critical compressive stress.

In all the recent welded ship casualties, as in previous ones, the steel fractured in a brittle manner, and when the fractures were extensive the failures were sudden, with all the characteristics of brittleness. It could not be assumed *a priori* from this that the brittleness of the steel was the sole cause of failure, since other factors, such as temperature, stress, geometric notches, or weld defects may have been abnormally adverse and combined to impose unreasonable duty on the steel. In most cases of important failures, however, the known conditions could not be regarded as abnormally adverse, and some of the steel involved conformed with the improved standards.

It became apparent, therefore, that the factor of safety against serious failure in some of these modern welded ships was inadequate, bearing also in mind the comparatively satisfactory performance of similar riveted ships. To decide what further measures should be taken to minimise the risk, it was necessary to re-examine, in the light of the most recent experience, the previous views on all the influential factors.

FACTORS INFLUENCING INCIDENCE OF FRACTURES

Rigidity.—It had long been thought that the difference in structural performance between welded and riveted ships might be due to the greater capacity of a riveted structure to yield at highly stressed regions by slip of the riveted joints, thus diffusing the stress concentrations, whereas in welded construction such relief must depend primarily on the capacity of the steel to yield. Extensive investigations by the Admiralty Ship Welding Committee failed to show any conclusive evidence supporting the belief; but it may be fairly deduced from the evidence of casualties that riveted joints are capable of slight movement which tends to relieve very high concentrations of stress, rendering the initiation of fractures more difficult.

Temperature.—These and all early investigations revealed that fractures were more frequent, extensive and brittle at the lower temperatures, and this trend is directly linked with the tendency of mild steel to behave in a brittle manner at low temperatures; but it had not been realised that some structural mild steels were inherently notch-brittle even at temperatures well within the service range, and that the temperature at which this brittleness appeared could vary very widely among steels which were, in the engineering sense, identical. This effect is clearly indicated in the casualty records. The temperatures for the cases here considered ranged, in the extreme, from about − 40° C to + 40° C, most being between 0° C and 10° C. At lower

Continuing

Research and Development

seasonal temperatures the air may be appreciably cooler than the sea, which has significance when the maximum service stresses are predominantly tensile at the deck; but severe storm conditions and consequent high stress are not likely to be associated with temperatures appreciably below 0° C. As this is statistically supported by the incidence of casualties, it seems reasonable to regard 0° C as a suitable minimum temperature on which to base safety for ordinary sea service —excluding, of course, Polar regions.

Externally Applied Stresses.—In most cases it is impossible to calculate the actual longitudinal stresses at the time of casualty, but many cases of brittle fracture in welded ships, some serious, have occurred under very low applied stress. An early well-known example was the Schenectady, which broke in two alongside the builder's quay under a calculated stress of only 4·4 tons per sq. in. Similar but less serious cases have continued to occur; one, a sudden fracture from the gunwale in a ship just completed on the building berth, when the applied stresses must have been negligible. It originated at a small defect in a member of no structural importance, a half-round rubbing piece. The sheerstrake plate to which it was connected was found to be brittle at the relevant temperature (− 2° C) though the composition was normal, the manganese/carbon ratio being 2·9. This case illustrates the danger of welded attachments to strength members and of permitting a plate of low notch ductility in the sheerstrake, and the unreliability of the manganese/carbon ratio as an index of toughness.

Impact.—The coinciding of exceptional wave impact with sudden fracturing at sea has been frequently recorded in the log books of casualty ships. Many fractures in the American ships were also associated with exceptional waves and slamming. This suggests that severe wave impact, superimposed upon the normal stress, may in many cases be the ultimate load which overcomes the resistance of the material to fracture initiation. Moreover, the high strain rate associated with impact may affect the capacity of the material to yield plastically.

Welding.—Since brittle fractures are more frequent and extensive in welded ships than in riveted ships, it is natural to conclude that effects associated with welding or their consequences must have an important influence. The main factors involved are: weld defects, residual stresses, metallurgical changes in heat-affected zones of parent material, and properties of weld metal.

Weld defects have frequently been found at the sources of fractures, but it is important to note that serious fractures have started in apparently sound welds or from very slight defects, undiscoverable and unavoidable in normal good shipbuilding practice. Since perfect workmanship is impracticable, it must be accepted that unsuspected sources of fracture initiation will exist.

The operation of welding gives rise to residual stresses, i.e., stresses which exist independently of the external loading. The general conclusions from the mass of investigation which has been made is that they are only significant when the parent metal is in a notch-brittle condition and when other necessary conditions, such as notches, are present. In such cases residual stresses cannot be ignored. It is significant that service fractures rarely follow the welds except where these are grossly defective.

Structural Design Factors.—In modern welded ships purely geometric notches, in the form of square corners to openings, have been largely replaced by rounded corners or their effects alleviated by other improved arrangements to minimise stress concentrations. These improves ments have reduced the incidence of fracture-from the corners of openings. Other forms or discontinuity, however, exist in the structure of in its component parts and experience continues to emphasise the necessity for close attention to such details. The connections of longitudinals at transverse bulkheads in tankers have recently been the subject of special study. All stress concentrations, however, cannot be eliminated by structural design.

STEEL REQUIREMENTS

It became apparent that some more definite control of the properties of steel was necessary; in particular, some measure of resistance to brittle fracture required to be formulated. Before 1949 the Steel Rules of Lloyd's Register simply required that the steel should be made by the open-hearth process and should comply with certain simple tensile and bend tests. No chemical composition was specified. In 1949, as a result of the early investigations on fractures, the sulphur and phosphorus contents were limited to 0·06 per cent, the manganese content was required to be not less than 2·5 times the carbon content for material over ½ in thick, and, for material over 1 in thick to be used in the main structure of welded ships, the properties and process of manufacture were to be specially approved.

There are broadly two methods which have been advocated to control the standard of notch toughness: (1) by specifying solely the metallurgy and manufacturing process, including composition, deoxidisation practice, heat treatment, etc.; and (2) by means of a mechanical test on the finished material with the minimum restriction on steelmaking practice. It is apparent that notch toughness is influenced in an extremely complicated manner by many variables. The composition of the steel is an important factor. Low carbon with high manganese and minimum phosphorus and sulphur contents are generally beneficial, while silicon, used as a deoxidising agent, is considered beneficial in the usual moderate amounts. Nitrogen, hydrogen, oxygen and trace elements also affect the desired properties. Aluminium additions, used in fine-grain practice, also have an important influence.

These effects depend not only on the amount of each element present, but on their mutual interactions and on the form in which they occur in the finished steel, i.e., whether in solution, combination, or separated in the form of non-metallic inclusions. Deoxidisation practices and rolling practices, which vary in different countries and different works, have considerable effect. Most mild steel is supplied in the " as rolled " condition, to which it may have cooled from a high finishing temperature, and during this stage significant changes occur; normalising is generally beneficial.

In view of these complications it was concluded that to control effectively the requisite quality of the steel solely by a metallurgical and process specification would be impracticable. Opinions, particularly in Europe, have increasingly favoured this conclusion and there is now wide agreement that the second method of control is to be preferred. Technical opinion has continued to be divided on the most suitable form of test and acceptance criteria, but the need for a test became so urgent that some basis had to be found from an empirical appraisement of available knowledge and experience.

All the available production tests may be arbitrarily divided into two groups: (*a*) notched impact tests, like the Charpy and Izod, which measure chiefly the ductility of the metal at the root of a particular standard notch; and (*b*) static notched tests, like the Tipper and van der Veen, in which the main indication is the type of fracture which occurs when a standard notched specimen is subjected to a standard type of static loading.

It is difficult to initiate a brittle fracture in ordinary notched tensile tests, irrespective of the sharpness of the notch; but, once fracture has been initiated, its propagation occurs without the need for additional external force or energy. This leads to the concept of an " initiation barrier " which must be overcome, after which propagation is automatic if a certain minimum stress is maintained and the material is in a condition which permits brittle fracture. The initiation and propagation energies vary to some extent independently. One steel at a given temperature may have a high initiation energy and low propagation energy, while another steel may show the reverse.

Impact tests such as the Charpy and Izod register only the total energy required to break a small specimen; they can give no indication of the proportion of energy consumed respectively by initiation and propagation, and it is not possible, by considering the total energy, to determine whether the fracture was ductile or brittle. It follows that the impact test cannot give a satisfactory measure of the resistance to propagation.

Since crystallinity in a fracture is always a manifestation of brittleness, it might be expected that fracture appearance would be a more definite guide. This led to the development of fracture appearance tests such as the Tipper notched tensile, the Navy tear test, the van der Veen slow notched bend test, and the Pellini explosion bulge test. Investigations in the United States, however, showed no acceptable correlation between the transition ranges found by the explosion bulge test and the energy absorption shown by the Charpy test, and it was concluded that Charpy energy, as an acceptance criterion, required some other test to determine where to assess each class of steel on the Charpy energy curve. Similar conclusions were reached in comparing Charpy energy and Tipper tests, and in studying the relationship between energy and fracture appearance in the Charpy test itself.

From a general analysis of the available data, it was concluded that the Tipper test, which relies primarily on the character of fracture, gives a better correlation with service experience than does the energy value in the impact tests; and that, in the impact tests, the character of the fracture gives a better correlation than does the energy. These conclusions were not relied upon fully, however, but only to the extent of postulating that the character of the fracture should always be taken into account. But the choice of an acceptance test for inclusion in a specification, already narrowed by the basic condition that the test should be simple, rapid, and economical under production conditions, was further restricted by the condition that it must be widely known and acceptable to steelmakers. The Charpy test, therefore, must be the first choice.

Since it would be impracticable to perform the test at more than one temperature, it was decided to adopt zero Centigrade; this temperature was shown to be significant in relation to service, and it could be readily reproduced in a test house and checked by the surveyor. By plotting the impact test data in terms of the two positive attributes, energy and percentage of fibrous area in the fracture, a limit for each criterion was derived which would exclude the majority of the " failure " points. This method led to the choice of 35 ft lb minimum energy and 30 per cent minimum fibrous fracture.

The facts on which these decisions were based were fully considered by the special technical panel, formed by representatives of the various interests concerned, and the findings were then embodied in a specification which, after approval by the Technical and General Committees of Lloyd's Register of Shipping, became a mandatory part of Lloyd's Rules on December 13, 1957, replacing the old Rule P.403.

Since the significance of fracture appearance and its influence in some steelmaking procedures has not previously been widely appreciated or studied, it was considered necessary to postpone the compulsory application of the 70 per cent maximum crystallinity criterion for the acceptance or rejection of material from individual casts; full compliance was to be aimed at.

Though the new specification relies primarily on production tests, it has been considered desirable to include certain limitations on the chemical composition, to ensure weldability. These limits are on the maximum carbon, silicon, manganese, phosphorus and sulphur, and are sufficiently broad to admit a wide range of steelmaking practices without permitting compositions known to cause difficulties in welding.

LABORATORY FOR STUDYING A DANGEROUS MATERIAL

Metallurgy and Fabrication of Beryllium

*By T. Raine,** B.MET., PH.D., A.R.I.C., F.I.M., *and P. P. Starling,** ASSOC.M.C.T., M.I.E.E.

Owing to the toxic nature of the metal beryllium and its compounds special precautions have to be taken in its manipulation during manufacture and fabrication. The exposure of operators to air polluted by the metal is rigorously prohibited as inhalation of this air can lead to chest diseases. Dermatitis may also result from the handling of beryllium and its compounds. The nature of the precautions taken in planning and equipping a laboratory for the study of beryllium, and the provisions made to ensure cleanliness and absolute freedom from contamination are described in the present article.

The metal beryllium is particularly attractive to the nuclear-power engineer because of its very low neutron capture cross-section of 0·009 barns per atom. This means that fewer of the valuable neutrons emitted during fission in a nuclear reactor are wastefully absorbed. Beryllium also possesses good resistance to oxidation at temperatures of up to 600 to 700° C, and another advantage from the point of view of nuclear engineering is that it is compatible with uranium at temperatures of the order of 500-600° C. Because of the limited information available on the properties of beryllium and the non-existence of fabrication facilities outside the United Kingdom Atomic Energy Authority, the Metropolitan-Vickers Electrical Company Limited, Trafford Park, Manchester, 17, some time ago decided to construct a suitable laboratory to enable these matters to be investigated. It was stipulated that the laboratory should be capable of determining properties, developing fabrication techniques, and manufacturing prototype reactor components.

Since beryllium is a toxic metal special precautions had to be taken. The most dangerous aspect is that the inhalation of the metal or its compounds can lead to acute or chronic chest diseases, so that exposure of the operators to polluted air is prohibited. The handling of beryllium or its compounds can also result in a form of dermatitis.

For work on beryllium to be undertaken with safety it is necessary, therefore, that the laboratory be specially planned and equipped. Prevention of chest diseases among operators can be assured by careful attention to air conditioning, while insistence on a very high degree of cleanliness of personnel through the provision of special clothing and washing facilities eliminates the risk of skin diseases.

The basic requirements of such a laboratory are as follows:—

The interior surfaces must be smooth and free from unnecessary projections, so that they can be kept clean with a minimum of effort.

The building must be reasonably airtight so that the only air entering or leaving can be filtered.

Entrance to the building should be restricted to a route which provides facilities for changing clothing, bathing and washing.

The installation of services and equipment must be planned so that entry into the building for maintenance purposes is reduced to a minimum.

* Research Department, Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17.

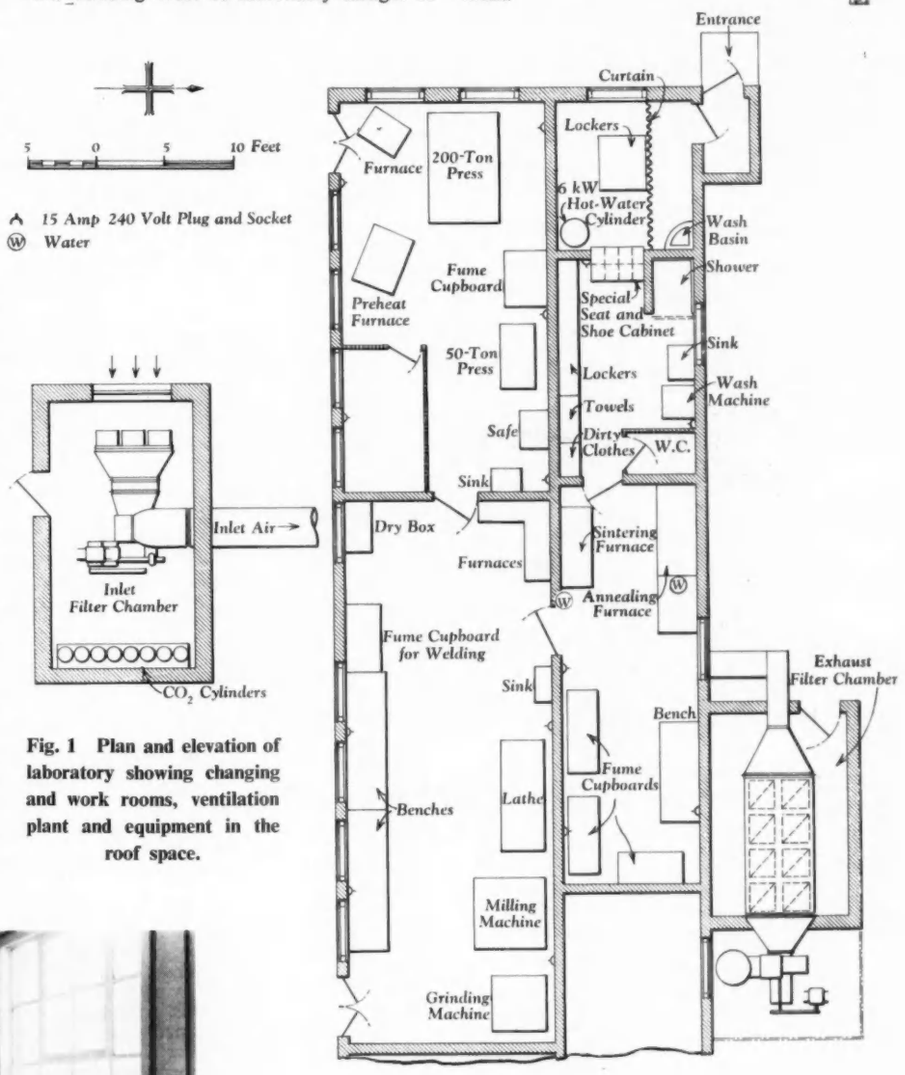
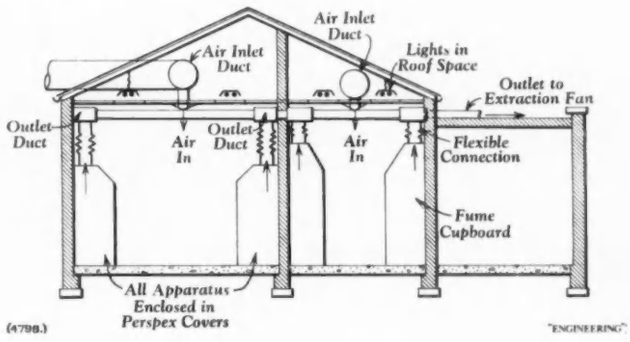


Fig. 1 Plan and elevation of laboratory showing changing and work rooms, ventilation plant and equipment in the roof space.

Fig. 2 View of changing rooms. The stile, in the form of a shoe cabinet, separates the clean room in the background from the washing room in the foreground. The lockers for normal clothing are seen in the background and those for working clothes on the left.



Continuing

Research and Development

The interior should be subdivided in such a way as to enable sections to be isolated and cleaned, when it becomes necessary to maintain or modify the plant.

A highly efficient ventilation and air-filtration system is essential.

In order to provide the necessary specialised laboratory facilities as quickly as possible it was decided to adapt and convert a part of an existing single-storey building. Although this affords less floor area than was desirable, it was, nevertheless, considered adequate to cover the early stages of the work.

The building, which is shown in plan and elevation in Fig. 1, was already provided with a wall dividing it into two unequal areas, one of these measuring 16 ft by 68 ft and the other 10 ft by 57 ft, and it was therefore decided to adapt the interior to conform to this subdivision.

After stripping out all the existing services, three new walls were built, dividing the whole into four separate areas, and an entrance vestibule was constructed. The concrete floor was made good, asphalted, and finally covered with linoleum. The walls were plastered and a plasterboard ceiling was built in beneath the roof-truss tie members, 12 ft above floor level, leaving a triangular space beneath the pitched roof. All corners at floor and ceiling were coved, projections and dust-collecting ledges eliminated as far as possible and the whole interior finished with hard gloss paint so that a clean, smooth finish was obtained.

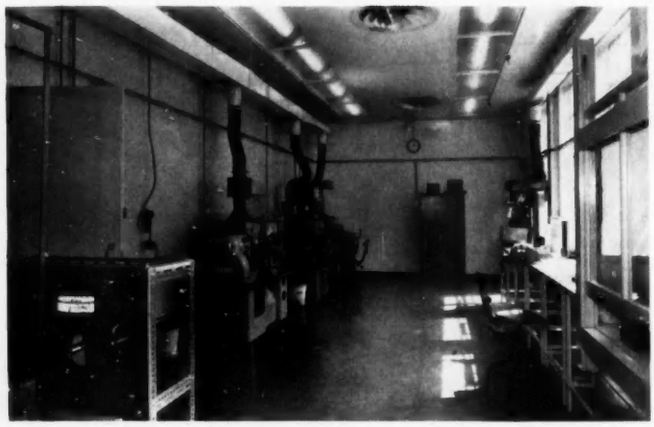


Fig. 3 (below) General view of machine shop, showing enclosed and hooded lathe, milling machine and grinding machine, and, on the left, a furnace.

Double glazed windows were fitted to the existing window openings, the inner panes being sealed into a smooth rounded framework. The ceiling was provided with a series of flush fitting glazed panels which admit artificial light to the building from fluorescent tubes located above them.

All the service mains are located in the roof space, including fuse boxes, so that they are readily accessible for maintenance from catwalks running above the ceiling. The fluorescent tubes may also be replaced from these catwalks.

Supply cables and pipes are taken from these service mains through bushes in the ceiling to the rooms below, being spaced a suitable distance from the wall to facilitate cleaning. The necessity for entering the building for maintenance purposes is thus reduced to a minimum.

The services available are electricity, three-phase and single-phase, hot and cold water, and compressed air.

The entrance vestibule, which acts as an air lock, gives access to a pair of changing rooms separated from each other by a stile. The first, or "clean" room, is provided with lockers for normal clothing and clean working clothes and the second room with lockers for working clothes, a shower bath, water closet, sink, and washing machine. The stile provides storage space on the "clean" side for outdoor shoes and on the other side for working shoes. Fig. 2 shows a general view of these two rooms.

The second changing room gives access to the three working areas, the relative positions and purpose of which can be seen in Fig. 1.

The two doors shown in the south wall are normally kept sealed but serve as emergency exits in case of need. They were also necessary initially for the installation of equipment and machines. The doors at the east end open into a fenced area and this is used for the storage and treatment of waste, or its preparation for disposal.

Ventilation is effected by warmed air which is introduced into the building through distributors in the ceiling, the ducting from which these are supplied being located in the roof space. The fan, heater and filter bank are conveniently arranged in an existing building nearby.

The exhaust fan and filter bank are located in a small annexe on the north side of the laboratory, the outlet being connected to a 30 ft chimney and the inlet to a system of trunking carried round the interior of the laboratory just below ceiling level. This trunking is provided with a number of ports controlled by dampers, connected by means of flexible ducting to the various pieces of equipment in the laboratory which are provided with hooded enclosures, or confined within fume cupboards.

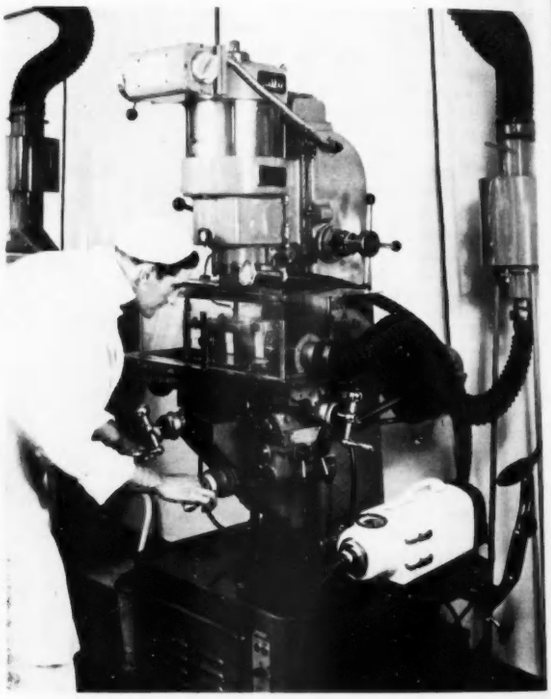


Fig. 4 (right) Vertical milling machine with transparent protecting enclosure. The separator inserted in the extraction line to prevent liquid being carried to the final air filter is seen on the right.

In this manner, all air leaving the building is forced to pass via the hoods, so that any dust or fumes produced are carried away from the operative. To reduce further the dust hazard, all cutting and machining operations are carried out wet and in such cases a separator is inserted in the extraction line to prevent any liquid from being carried to the final air filter. Fig. 3 gives a general view of the machine shop and Fig. 4 shows a vertical milling machine with its protecting transparent enclosure, and the separator can be seen in the air duct. All fume cupboards are connected to the extract duct.

The ventilation system is designed to give about 20 changes an hour and to maintain a slightly negative pressure within the building. The filtering of the exhaust air is performed by a bank of eight Vokes No. 55 absolute cells, which are arranged so that their removal and replacement can be effected with a minimum of danger. The incoming air is filtered by a bank of 18 Vokes K.600 Compak filters, which remove particles of dust that would otherwise prematurely choke the exhaust filters. An alarm bell gives warning in the event of the failure of the exhaust system.

To protect the building against fire risk, an automatic CO_2 system has been installed. This has been divided into three zones, one on each side of the main dividing wall, and one in the roof space. Upon operation, an alarm is sounded in the laboratory and in the company's fire station, the ventilation plant is shut down, and CO_2 released in the zone concerned. As additional precautions, all woodwork has been treated with fire-retarding paint, and certain of the lights can be switched on from outside the building by the patrolman, who can view the interior through the windows.

Cleaning is carried out continuously, mainly with the aid of vacuum cleaners, which exhaust into the extraction system. Electric polishers are also employed. The washing machine referred to earlier is used for washing the working clothes and towels which, after "spin drying," are taken from the building for final drying before being returned to the "clean" room for re-use.

Access from outside the building is provided to the roof space, so that lamps can be replaced, fuses repaired and so on without interfering with the work of the laboratory. Should a machine or piece of equipment within the laboratory require attention, the area in which it is located can be isolated, cleaned, and the item in question decontaminated, after which the area can be entered by either of the emergency doors or the changing room entrance without the necessity of donning special clothing or taking any of the precautions necessary when the normal work of the laboratory is in progress.

The equipment installed in the laboratory comprises plant for the handling and treating of beryllium powder in air-conditioned glove boxes, an example being shown in Fig. 5. There is also equipment for cold pressing, hot pressing and forging. Furnaces installed provide for vacuum or argon-atmosphere melting, annealing and sintering. Dust-extracted machine tools permit turning, milling and surface-grinding operations to be carried out. The preparation of specimens for metallographic examination is done in a train of equipment enclosed in fume cupboards.

Other equipment measures the compatibility of beryllium with other metals and gaseous atmospheres at high temperatures.

Where it is possible to handle beryllium in a sealed-up container of non-toxic material, operations can be undertaken outside the laboratory. For example, the rolling of sheet, or extrusion can be done with the beryllium metal inside welded steel containers. Using this technique, beryllium is being produced in rod or sheet form using a conventional rolling mill and extrusion press situated in another part of the department.

Welding investigations have also been provided for, and the equipment includes an a.c./d.c. set for fusion welding under argon, a high-temperature pressure welding plant, and a resistance welding machine.

The maximum permissible concentrations of beryllium in air as recommended by the Advisory Committee of the United States Atomic Energy Commission are as follows:

(1) The in-plant concentration of beryllium in air should not exceed 2 micrograms per cubic metre as an average concentration throughout an eight-hour day.

(2) No personnel should be subjected to a concentration greater than 25 micrograms per cubic metre for any period of time however short.

(3) The out-of-plant concentration of beryllium in the atmosphere should not be greater than 0·01 micrograms per cubic metre. Although the laboratory is designed so that these limits shall not be exceeded a further check is made by taking samples of air from time to time, both inside and outside the laboratory. The method of sampling is to draw air through a specially prepared filter paper measuring the amount of air drawn through it. The amount of beryllium deposited on the filter paper is then determined by spectrographic analysis. The concentration of micrograms of beryllium per cubic metre of air can then be calculated.

When it is necessary to decontaminate part of the beryllium laboratory or objects for removal from the toxic area, the effectiveness of decontamination is checked by a smear-sampling technique. To do this a damp filter paper is wiped over representative portions of the surface area after the completion of the cleaning. The filter paper is then analysed for beryllium.

The works medical officer is responsible for the medical supervision of personnel engaged in the laboratory. Before anyone becomes exposed to beryllium they are given a thorough medical examination which is repeated at frequent intervals.

A complete change of clothing, including underclothes, is provided for those working in the laboratory. For people making short-term visits, overshoes and laboratory coats are provided. All the clothing is washed daily on site.

At the end of each day, all personnel actually working on beryllium are required to take a shower-bath. Eating, drinking and smoking are prohibited in the restricted areas.

Gas masks are available should anyone be required to work on such items as ducting, etc.

In the authors' opinion, a building designed specifically as a beryllium laboratory would consist of a single-storey central portion with a roof space above the ceiling, flanked by a service corridor on each side. Provision would be made at one end of the building for normal "clean" laboratory and office accommodation and adjacent to this would be the main entrance, changing rooms and laundry. The ventilation plant and filters would be located in an annexe attached.

Airtight access doors would be provided at intervals from the laboratory into the service corridors, and machines and major apparatus would be arranged so that after cleaning they could be withdrawn from the laboratory through these doors into the service corridor for maintenance and servicing.

All services, together with any ancillary apparatus, would be in these corridors, feeding the laboratory through the wall when required.

Fig. 5 Air-conditioned glove box in which beryllium powder is handled and treated.

Where practicable, services into the laboratory would be in duplicate, to avoid maintenance difficulties in the event of the failure of a service point. The artificial lighting and inlet ventilation duct would be housed in the roof space over the laboratory, and the extract duct within the laboratory.

It will be noted that, with the exception of the service corridors, most of the provisions laid down for an ideal laboratory have been realised in the present structure.

MEASURING PUMP EFFICIENCIES BY THERMOMETRY

*By J. V. H. Holt**

In one of the many plants operating in the Billingham factory of Imperial Chemical Industries Limited, it is necessary continuously to pump some 5,500 cu m/h of water against a pressure of 55 atmospheres. For this duty there are installed a total of 18 multi-stage centrifugal pumps driven by steam turbines through reduction gearing. Fifteen of these pumps were manufactured by Mather and Platt Limited some 30 years ago; the remaining three, which have been in service for only two years, were supplied by Klein, Schanzlin und Becker A.G.

The cost of power to drive these sets amounts to some £250,000 per annum and it is, therefore, of prime importance that each pump is maintained at the optimum standard of efficiency. For a considerable number of years, the period between successive overhauls of any one pump was determined by the number of hours during which it had been actually operating. Evidence accumulated over these years showed clearly that this was not a correct basis; there were wide variations in the state of wear of the various parts. A more direct method of assessment was therefore sought. It was realised that a direct measure of the inefficiency could be made by measuring the temperature rise between suction and delivery. A simple calculation showed that it would be necessary to measure a temperature difference of approximately 0·5° C and that an error of 0·02° C in this measurement would amount to an error of 1 per cent in the final calculation of efficiency.

Initial tests were carried out early in 1950 using two Beckman thermometers. They were inserted in sheaths set across a diameter of the suction and delivery pipes and were arranged to measure the temperature of the water near the centre of the flow cross-section. The results were very promising in that on a pump which had been recently overhauled, the efficiency calculated by the temperature difference method corresponded closely to that from the maker's characteristic curve. However, two difficulties were soon apparent. The first involved the calibration of the thermometers which could be carried out only in the laboratory. The second was inherent in the thermometers themselves. Being made of glass, the rate of breakage was high and, as a routine method of measurement capable of being carried out by comparatively unskilled labour was the objective, the Beckman thermometers had to be discarded.

The present method is to measure the temperature difference of the water between the suction and delivery side of the pumps, and not the actual temperatures. This is done by means of two electric resistance elements which form part of a Wheatstone bridge circuit. They are connected to an indicating instrument, the scale of which has been modified in such a way that it can be read to $\pm$ 0·005° C. The instrument keeps the bridge in balance and the amount required to keep it in balance is read off directly on a scale calibrated directly in °C. In this manner, only robust equipment is used and it is possible, therefore, to use comparatively unskilled labour for the tests.

When carrying out an actual test, the pump to be tested is run up to full speed and left there for an hour to enable the temperatures to settle. The two resistance thermometers are then inserted into mercury-filled sheaths in the inlet and outlet pipes and the temperature difference measured to 0·01° C. At the same time the suction and delivery pressures are measured. The thermometers are then reversed and another set of readings taken.

The average readings are then used to work out the pump efficiency from the equation—

$$\text{Efficiency} = \frac{100 \times (\text{delivery pressure} - \text{suction pressure})}{(\text{delivery pressure} - \text{suction pressure}) + 41{\cdot}3 \times \text{temp. diff.}}$$

the pressure being measured in atmospheres and the temperature in °C.

It is known that, while the instrument has a degree of accuracy of $\pm$ 0·01° C, the method of inserting a resistance thermometer (itself in a sheath) into a mercury-filled sheath in the pipeline is comparatively inaccurate. However, all that is aimed at in this simplified method is to obtain a comparison between pumps, and no absolute figures are expected. The method may, and does, give results fluctuating $\pm$ 2 per cent in terms of efficiency but makes up for this crudity in being quick, cheap and capable of being used by plant personnel with little supervision.

It is appreciated that there are serious limitations in the use of this method. So far it has been successfully applied only when comparing the efficiency of the Mather and Platt pumps. When attempts have been made to use a similar technique for measuring the efficiency of other high-head pumps and Pelton wheels, the results have been seriously in error. This is possibly due either to failure to measure a mean representative temperature or to varying amounts of conduction along the thermometer sheaths. Further investigations are being undertaken to eliminate these errors. Nevertheless, the original objective has been achieved, and has not only shown that the measurement of efficiency of high-head hydraulic machinery can be done simply and as a matter of routine, but has made it possible to save both on power consumption and maintenance labour by overhauling pumps only when the efficiency has fallen to the predetermined figure.

* Imperial Chemical Industries Limited, Billingham Division.

Book Reviews

THROUGH THE CHALK TO FRANCE

The Channel Tunnel. By HUMPHREY SLATER and CORRELLI BARNETT. *Allan Wingate Limited, 12 Beauchamp Place, London, S.W.3.* (21*s.*)

For 150 years men—and not a few women—have dreamt of a tunnel driven under the English Channel to join England with the Continent. All that time men have been willing to find the necessary money and have thought the venture worth while. But opposition to the tunnel—principally from Britain's Imperial Defence Committee—has so far prevented anything more than a tentative beginning being made when, in 1870, short pilot tunnels were driven out from the shore on both sides of the Channel. Throughout the period dozens of alternative proposals—bridges, large high-speed ferries, sunken tubes and floating causeways—have been put forward for providing a permanent means of getting to and from the Continent, but none has retained the grip on the imagination of the public and engineers alike as has the Channel Tunnel. As the cost of the project has risen with the passing years so has its commercial potential. With every introduction of new materials and construction techniques the risk factor which separates the cost and the possible return to the sponsors has been reduced until, soon, inevitably, the prize to be won will outweigh the cost. Changes in the military climate have shattered the traditional plank of the opposition—the defence of Britain.

The history of the Tunnel, the changing economic conditions and the personalities who have joined issue over the project are thoroughly ventilated in this new book by the late Humphrey Slater and Mr. Correlli Barnett. Neither of the authors has had the benefit of a technical education and their book—perhaps in consequence of their non-engineering background—makes most engaging reading. Anyone who has attempted to study the formal documents and reports will appreciate how accurately and refreshingly the authors have accomplished their task. Circumstances and personalities are introduced through the pages with the clarity of a novel and so rarely found, unfortunately, in technical reports. Yet the book has a soundness and restrained optimism (apart from the authors' liking for Basdevant's stupendous design for a combined road and railway tunnel) which will appeal to engineers. Only two small points jarred: the authors' dated use of the term "ferro-concrete" and their references to the "Institute" of Civil Engineers.

The most thorough analysis of the difficulties to be met is still that undertaken by a panel of consulting engineers in 1930 on behalf of a British Government committee and, though the economic outlook is now much different, many of the 1930 findings are still valid. That panel stated a preference for twin tunnels of 18 ft 6in diameter and established the most likely route—by no means the shortest—which is thought to follow a belt of chalk that is structurally stable, contains very little water and is easily mined. Though it cannot be guaranteed that this formation is unbroken across the Channel, it is certain that no better route could be devised. More direct routes would almost certainly cut through belts of saturated upper chalk or, even worse, have to cross the beds of submerged rivers. They would also require excessively steep approach ramps.

The methods for constructing the tunnel would probably be much as those conceived before the turn of the century. Boring would be done by a self-contained tracked vehicle with rotating knife blades peeling away the chalk across the full diameter of the working face. The prototype of this machine is that designed by an Englishman, Colonel Beaumont. To get rid of the spoil, it was proposed by M. Philippe Fougerolles, a Frenchman, to mix the chalk peelings with water and pump the resulting slurry out into the sea bed. This would mean that the spoil would only have to be transported back along the tunnel as far as the pumping points and not out through the tunnel entrances. (With the strong currents in the Channel, there is a fair chance that some of the slurry would end up in the mouth of the Crouch or the Scheldt.) Originally it was proposed to line the tunnel with cast-iron segments and the 1930 committee preferred this to reinforced concrete. Since that date, however, concrete technology has advanced and plain (unreinforced) concrete segments, self-interlocking, and erected continuously by a machine, would probably be used.

The 1930 committee also plumped for a railway tunnel—not surprisingly since from both the French and British sides the principal sponsors were railway companies. Since the war, however, there has been such an immense growth in road traffic that public opinion and transport authorities alike must look to a road tunnel. The factor which will probably determine this issue is that of ventilation. A considerable body of technical opinion believes that no forced ventilation would be required for a railway tunnel where electric stock is operated. On the other hand, a road tunnel for internal combustion engine vehicles would make a most comprehensive system of forced ventilation and air cooling essential. It is likely, however, that the density of rail traffic will be such that some ventilation would now be considered necessary, though not on any comparable scale as that for a road tunnel. For economic operation rail stock would be wanted that could be readily used for the transport of road vehicles—but experience of this exists on both sides of the Channel.

Some difference of opinion exists on the necessity—or otherwise—of driving a pilot tunnel in advance of the main tunnels. The most cogent reason for the pilot tunnel is to prove the route. For an expenditure of perhaps £12 million it could be shown if there was any considerable fault to be met before the main tunnels were committed—costing perhaps £200 million to drive and equip. There is, however, another good reason for completing the pilot tunnel well in advance of the main tunnels: the ordnance datum on either side of the Channel is not related to that on the other with any certainty and it could be that tunnels driven from the two sides would be out-of-level by an embarrassing amount—unimportant in the pilot tunnel, but almost impossible to rectify in the main tunnels.

Opposition to the Tunnel has come in the past from British military circles who were frightened for the defence of the country. But in 1940 the Tunnel might well have saved the B.E.F. and enabled much of the stores and equipment to be retrieved also. In 1941 the high command worried lest the Germans completed a tunnel and its construction was again considered from this end as an aid to the "Second Front"—an idea that was abandoned because of the time it would take to put into effect.

From the French side—and the French, collectively, have always been more in favour than the British—there now comes the Suez Company, dispossessed of its canal by Colonel Nasser, looking for a new outlet for its capital and activities. The Supreme Headquarters, Allied Powers Europe, SHAPE, responsible for the defence of much of Western Europe, including both Britain and France, has given their official blessing to the project. The opposition now consists primarily of those sections of British industry that oppose the United Kingdom taking any part in the formation of the European free trade area: they see cheap goods and agricultural produce coming here from the Continent and undermining the country's economy. Yet the converse is also true, and if the go-ahead sections of our industry are to export to the Continent, then the Tunnel is as vital as are the new motorways just beginning to be built.

Before the Tunnel can become a fact, sanction will still be required from the House of Commons Yet *there* is real hope. For in the House there still sit two men who supported the cause in 1930 when the Tunnel project was debated and lost by only seven votes: Sir Winston Churchill and Mr. Aneurin Bevan. Perhaps it will yet come about that the Member for Woodford and the Member for Ebbw Vale will join together to support a proposition that, for good or bad, would hasten a United States of Europe.

VACUUM VOLUME

Pressure Measurement in Vacuum Systems. By J. H. LECK. Published on behalf of The Institute of Physics by *Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (30*s.*)

High vacuum techniques are concerned with the production and measurement of very low absolute gas pressure. The removal of the air (or for that matter any other gas) from a vessel allows the unhindered passage of all atomic and subatomic particles such as electrons, metallic atoms or the molecules of vapour leaving a liquid surface. At sufficiently low pressures the possibility of collisions with the remaining gaseous molecules is much reduced. To this end pumping equipment is now available with high speeds even at the lowest pressures and vacuum gauges have been designed to evaluate the pressure levels attained.

The first important industrial application of vacuum techniques was in the manufacture of sealed-off electronic or electric devices such as tubes for radio and television, electric lamps, and X-ray tubes. But vacuum has always been of importance in a much wider field—in purely scientific investigations in the laboratory. Thus a high degree of vacuum is required for the successful operation of analytical machines, for example, electron microscopes and mass spectrometers. Vacuum is used on a large scale in the particle accelerators of nuclear physics and on a small scale, but with the highest refinements, in the study of "clean" solid surfaces uncontaminated by contact with any gas. On the other hand, vacuum has become important in industrial processes as diverse as those involving distillation, dehydration, impregnation, metallurgy, and vacuum coating for optical and decorative purposes.

All these applications have had the effect of converting vacuum techniques from an obscure laboratory art to an established industry. The design engineer to-day has at his disposal a comprehensive selection of standard manufactured articles involving components, pumps and instruments and including complete pumping systems, leak detectors and specialised plants. The use of vacuum gauges in the measurement of low pressures is clearly a most important factor in any high vacuum process, as are the related techniques of process control based on pressure, and the location of air leaks in vacuum apparatus using pressure-sensitive devices.

Pressure, in terms of the force applied to a surface, is measured directly in liquid manometers and less directly in manometers depending on the deformation of an elastic element, for example, a diaphragm. For the measurement of the lowest absolute pressures it is necessary to use an indirect method in which a quantitative

change of some physical property is measured. A variety of high-vacuum gauges have been made based on Boyle's law, the change in conduction of heat through the gas, gas discharge and ionisation, the change in gas viscosity, and the radiometer force. In this way, absolute pressures from atmospheric down to less than 10^{-12} atmosphere are measured, though with some uncertainty and lack of precision when compared with measurements in other branches of engineering.

It is a sign of the growth of vacuum technology that for the first time a book has been published dealing exclusively with modern vacuum gauges. An immediate criticism springs from this in that there is no proper introduction to the subject as a whole and the reader is almost straightway confronted with the details of the different instruments. This makes for concise but difficult reading, especially as the underlying physical principles (for example, the relevant kinetic theory of gases) are taken for granted or given as references to the literature. The book is fairly advanced and specialised but, although it gives the impression of completeness, it is not comprehensive and closer examination reveals a great number of omissions which the title of the book would not have lead one to expect.

There is very little discussion on the fundamental quantity being measured, i.e., pressure itself, or on the units employed. The measurement of partial pressures of gases and vapours is only incidentally mentioned with no mention at all of important tools such as the mass spectrometer. Only one method of vapour-pressure measurement is referred to. With the recent interest in automatically-controlled plant it is disappointing to find little information on switching devices depending on pressure levels. There is no mention of the use of vacuum gauges for the location of air leaks. The viscosity manometer is dismissed as being primarily of " historic interest " and there is no discussion of the ordinary cold cathode discharge, i.e., the discharge tube. Similarly there are smaller omissions in the actual topics selected; and among some 200 references at the end of the book a number of important contributions have not been included. Particularly it could be useful to some readers to know that there are three journals in the West dealing exclusively with vacuum, that a number of books dealing with vacuum as a whole contain chapters on vacuum gauges, and that review articles on vacuum gauges or related subjects have occasionally been published. There is no reference at all to the yearly symposium on vacuum techniques in the United States, the papers of which are regularly published in book form and, apart from Mr. Leck's own work, there is no reference later than 1955.

In the present book a detailed discussion of vacuum gauges deals in separate chapters with mechanical manometers, thermal conductivity gauges, ionisation gauges and the Knudsen gauge. This is followed by a short discussion on surface reaction techniques, which is valuable because of its connection with the very low pressure work that has recently received renewed interest. Finally there is a short note on gauge calibration. A useful subject and name index is included but the latter does not contain all the names mentioned in the list of references. The printing of the book is to the usual high standard of the publishers and the diagrams are very clear, though there is only one photographic illustration of an actual gauge, which is so poorly reproduced as to be hardly worthwhile.

The book marks an important step in the publication of specialist literature on aspects of vacuum techniques. It has somewhat failed to provide a truly comprehensive treatise on pressure measurement but the subjects discussed should prove of considerable interest to the specialist.

NEW BOOKS

Directory of British Rubber Manufacturers and Products. 1958 edition. *Federation of British Rubber and Allied Manufacturers*, 43 *Bedford Square, London, W.C.*1. (25*s.*)

The third edition of this well-produced Directory is made up of an alphabetical list of manufacturers, with addresses and details of overseas representation, a classified list of products, indexed alphabetically in English and in French, Spanish and German, and an indexed section of advertisements. The Directory is primarily designed for overseas importers, to whom it is available free of charge, but a limited number are available in this country at 25*s.* per copy.

Air Pollution. Based on papers given at a Conference held at the University of Sheffield, September, 1956. Edited by M. W. THRING. *Butterworths Scientific Publications*, 4 *and* 5 *Bell-yard, London, W.C.*2. (42*s.*)

The magnitude of our national air-pollution problem may be gauged from the fact that some 200 million tons of coal and upwards of 20 million tons of petroleum oil are used annually as fuel in Great Britain. Considerable strides have been made in recent years in methods of combating air pollution and some conception of the nature of the problem, and of how matters now stand, are given in the present volume. The aim has been to turn the papers presented at a conference on air pollution into a stimulating and readable book. Numerous illustrations, both line and half-tone, are included.

Dynamic Properties of Vulcanised Rubber: 5, Shape Factors and Functions in Rubber Engineering. By A. R. PAYNE. Research Report No. 84. *Research Association of British Rubber Manufacturers, Shawbury, Shrewsbury, Shropshire.* (21*s. non-members.*)

The effective stiffness of a rubber component can be expressed as the product of three quantities, namely, the elastic modulus of the rubber, the degree of compression, and a " shape function " depending solely on the geometrical configuration of the component. Hitherto the shape function has been represented by a confusing variety of arbitrary factors. The report, however, contains data and methods which present a simple and logical means of calculating the force/deformation relationships for most of the commonly-used forms of component, given the one basic property of elastic modulus, either static or dynamic, according to the type of deformation encountered in service.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Plate and Sheet Metalworking. BRONX ENGINEERING CO. LTD., Lye, near Stourbridge. Press brakes in capacities from 20 to 1,000 tons, and bending rolls, of 3-roll pyramid or 4-roll initial pinch types. Two illustrated catalogues, with details of capacities, method of working, and tooling.

Food and Chemical Drying. KESTNER EVAPORATOR AND ENGINEERING CO. LTD., 5 Grosvenor Gardens, London, S.W.1. Spray dryer for liquids, slurries, and solids in suspension, which it delivers in powder form. Illustrated leaflet, with details of a range of sizes with outputs from 2·5 to 5,400 lb per hour.

Milling Machines. STANHOPE MACHINE TOOLS, LTD., 5-17 Haverstock Hill, London, N.W.3. Details of a range of milling machines and accessories made by Gambin & Cie., S.A.R.L., Billancourt, France, and distributed in Great Britain by Stanhope. Several illustrated leaflets describing different machines and fittings, including a copy-milling attachment and optical setting equipment.

Low Cost Buildings. SHERBOURNE ENGINEERING, LTD., Sherbourne Road, Birmingham, 27. Fabricated tubular steel roof trusses, in a range of standard spans, from 16 ft 8 in to 40 ft. Brochure with reproductions of working drawings of trusses and methods of roofing and supporting.

Bar Pointing. FRANK WHITELEGG, LTD., 304 High Street, Sutton, Surrey. Machine made by Th. Calow & Co., Bielefeld, Germany, for pointing bars from 12 to 60 mm ($\frac{15}{32}$ to $2\frac{3}{8}$ in) diameter. Illustrated leaflet.

On the Shelf

By Frank H. Smith

I often wonder what it must be like to work at the British Standards Institution, where, presumably, one can always be sure that the plug will fit the socket, where one's *derrière* will always be comfortably chaired, where, perhaps, the desks are all the same height. Now, I see, they propose to change over their stationery to conform to the accepted international "A series " which is already favoured in 26 countries. This means, of course, the adoption of a metric standard with its usual accompanying approximate measurement in inches.

The B.S.I. are adopting paper sizes A4, measuring 210 mm by 297 mm (approximately $8\frac{1}{4}$ in by $11\frac{3}{4}$ in) and A5 at 148 mm by 210 mm—exactly half A4. At least, the Institution say it is exactly half, but I make half of 297 to be 148·5, which puts the measurement half a millimetre out. If anyone wants further information concerning these international sizes he should get in touch with the B.S.I. at 2 Park Street, London, W.1, quoting CY(P) 4374.

The February-March number of the *Unesco Bulletin for Libraries* (price 3*s.* 4*d.* from H.M. Stationery Office) contains, *inter alia*, a select list of current periodicals that have appeared in the U.S.S.R. during 1952-57. This is not just a list that has been compiled by Western observers, but the work has been done by the Department for Bibliographical Registration of Periodicals of the All-Union Book Chamber in Moscow. And you can't get more authentic than *that*. The information given is: title, translation, editing body (when this differs from the publisher), place of publication, publisher, size, frequency, price per issue, and language, if other than Russian. The list is divided up into subjects and the price, by the way, is in roubles.

One would expect a hairdresser to have a most elegant tonsure, a dentist to have a lovely set of teeth, a tailor to be exquisitely garbed, and a columnist to write perfect English, I suppose. By the same tokens one would expect a paper-producing firm to sponsor the ultimate in house magazines, and, in the case of the *Bowater Papers*, published by the Bowater Paper Corporation Limited, Bowater House, Stratton Street, London, W.1, one is not disappointed. Nowhere is there an indication of working to a schedule. All the papers (one can hardly call them articles) have a bearing on the wood-pulp product, but they are written with a scholarship and illustrated by artists such as are not often found collected together between the same two covers. One essay in particular on the quatercentenary of the Worshipful Company of Stationers and Newspapermakers has two illustrations by A. R. Thomson, R.A., that have a depth of colour rarely seen in publications of this sort. The unusual nature of this production extends even to the acknowledgments, where every firm (and each chapter is produced by a different firm of printers), author and illustrator are given due credit—most deservedly.

Here is something gratis; Sciaky Bros. Inc., 4915 West 67th Street, Chicago, Illinois, U.S.A., offer a 50 page engineering report on *Tentative Design Standards for Resistance Formed Welds in Mild Steel.* Write to Public Relations, Department ER-MHF, at the address given.

In *The Times Review of Industry* for March there is an article entitled " Britain Needs More Professional Engineers." This, perhaps, is a glimpse of the obvious, but what is not so obvious is an opening remark of the author's in which he states: " What is an engineer? In Britain the title is confined to those who work mainly in metal. . . ." Had he said " is sometimes understood to mean " instead of " confined to " I might have agreed, but such statements as these help to confuse the layman who has difficulty in telling the difference between a member of a profession and an artisan.

Design

HYDRAULIC SYSTEM SIMPLIFIES CRANE CONTROL

Fig. 1 Twin bogie Booth diesel-hydraulic 10–15 ton rail crane. The hydraulic transmission and compressed air controls ensure smooth running and easy operation.

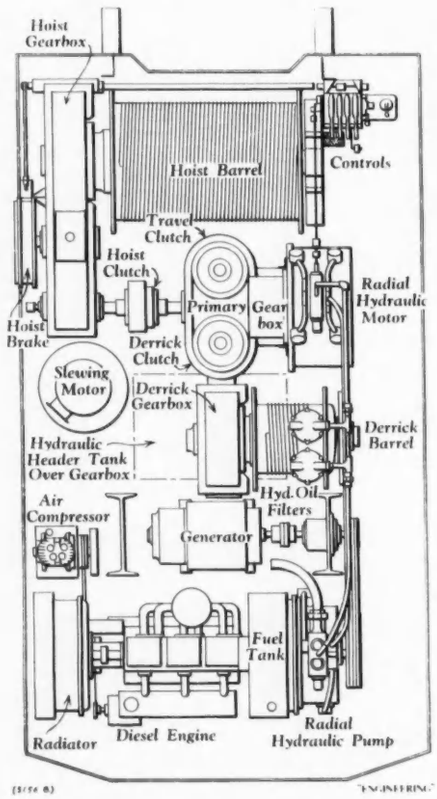


Fig. 2 General arrangement of diesel-hydraulic machinery on the crane superstructure which is designed to be virtually independent of the carriage.

It is not surprising that with the replacement of steam locomotives by diesel-electric and diesel-hydraulic locomotives on our railways that there should be further developments in the use of diesel engines for rail cranes. The diesel-hydraulic cranes now being manufactured by Clyde Crane and Booth Limited, Rodley, Leeds, for the British Railways Western Region, incorporate some novel features which provide for flexibility in design and ease of operation and control.

For this type of crane, power is supplied by a diesel engine to drive a hydraulic pump which transmits power by a pressurised mineral oil fluid system and control valves to a hydraulic motor coupled to the primary drive shaft. In this way, the inherent difficulty in reversing a diesel engine drive can be easily overcome by reversing the direction of fluid through the motor. The speed of the motor is varied by means of valve gear interposed in the pressure circuit which cut out a series of rams in the pump or motor from the hydraulic supply. By selecting fluid circuits in this way, motor speeds of 83, 166, 250 and 500 r.p.m. are obtained in the forward or reverse direction with the engine running at its full governed speed of 1,000 r.p.m.

COMPACT DESIGN

Compactness is an important consideration in the design of railway cranes where the width of the crane has to be kept within the restrictions of the railway loading g uge: in this case the hydraulic pump is mounted on the engine thus economising in space; further, the position of the engine in relation to the driving units is no longer so important, since the connexions for the hydraulic unit are made with pipes.

The general arrangement of the machinery is shown in Fig. 2. It is carried by a superstructure which is virtually independent of the carriage. The 16 ram hydraulic motor is directly coupled to the primary shaft of the main gearbox and provides the drive for the hoist, derrick, and travel motions. The needle type control valves and the large number of rams of the hydraulic motor ensure that the motion transmitted to the primary shaft is smooth and purely rotary. Because of its low power requirements the slewing motion is operated separately by an electric motor supplied from an engine-driven generator wound to give full excitation with the engine idling; full power is therefore available for slewing regardless of engine speed. The same generator can also provide current for lighting sets and any other electrical requirements.

Details of the primary gearbox are shown in Figs. 2 and 3 which also indicate the use of air-operated multi-plate friction clutches to operate the main motions of the crane. The main hoist gearbox is connected to an extension of the primary power take-off shaft through the hoist clutch (Fig. 2); double spur reduction gears are used. The hoist barrel is of solid drawn seamless steel tubing with rope grooves machined from the solid, and fitted with deep steel flanges. With the hydraulic transmission system, where the exhaust fluid can be throttled for braking purposes, loads can be hoisted or lowered under power without requiring a mechanical brake. However, a friction type hoist brake, pedal operated (Fig. 4), is provided on the intermediate reduction shaft for use under certain working conditions, and also serves as an additional safety precaution.

The drive for the derrick barrel is taken from the power shaft through the derrick clutch, and spiral, bevel and worm gearing. The worm and spiral gears are totally enclosed and an automatic Weston type brake is incorporated with the worm gears; the thrust from the worm shaft provides the braking load. The barrel is machine grooved and takes the rope in a single layer with sufficient coilage to lower the jib into a horizontal position.

UNIQUE TRAVELLING PERFORMANCE

The hydraulic transmission gives the crane a unique travelling performance. On the slow speed ratio, there is available a slow speed at full torque for inching and precision setting, while there is normal full speed at full torque for shunting duty. To move the crane quickly

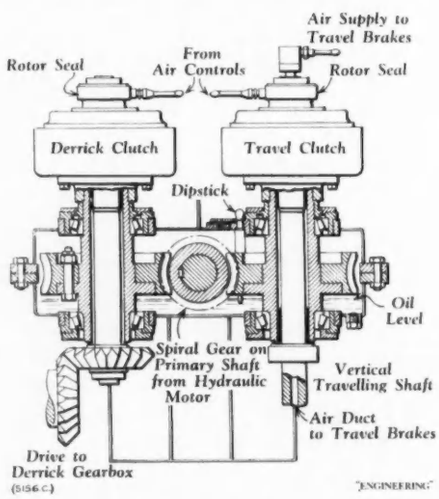


Fig. 3 Section through the primary gearbox, showing power take-off for derrick and travel motions.

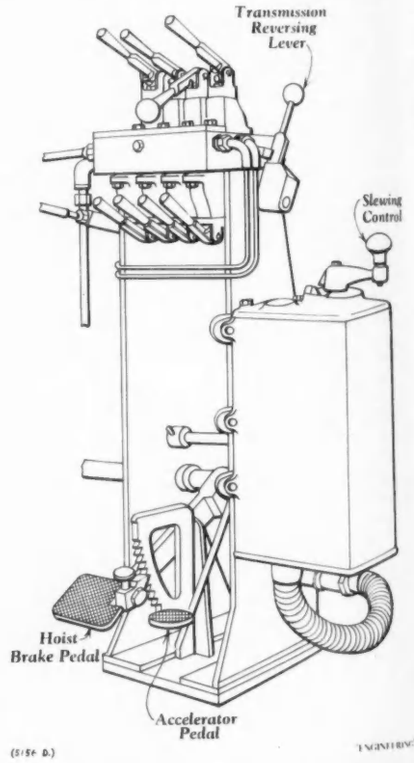


Fig. 4 Arrangement of crane-driver's controls. Valves open when levers are in the "down" position.

over long distances, a high speed on the fast ratio is used. Normally the crane is supplied on a four-axle twin-bogie carriage but other types of carriage can be supplied. The vertical drive between the superstructure and the carriage is taken through a splined shaft engaging on the quills at each end; this represents a marked advance over previous drives and enables the superstructure to be easily lifted off. Bevel gears have been replaced by hollow faced spiral gears running in oil in an enclosed gearbox, the drive from the gearbox to the carriage axles being transmitted by Hardy Spicer cardan shafts. Provision is made in the final draft for disengaging the pinions from mesh to enable railway cranes to travel in train.

COMPRESSED AIR CONTROLS

The arrangement of the crane controls in the driving cabin is shown in Fig. 4. Eight identical hand levers provide the compressed air controls for hoisting, derricking and travelling and for the travel and slewing brakes: the compressed air for these controls is provided by a Westinghouse compressor set driven by the engine. A hand-lever through linkages operates the reversing valve on the hydraulic motor; the hoist brake and engine accelerator are similarly operated by pedals.

Maintenance of the hydraulic pump and motors necessitates specialised attention and, in the remote event of these units becoming unserviceable, the manufacturers recommend that they should be returned with the seals unbroken and replacement units, which will be kept in stock, fitted. The L.E.H. hydraulic transmission used for the Booth diesel-hydraulic crane is manufactured by the Leeds Engineering and Hydraulic Company, Limited, an associate company of Clyde Crane and Booth Limited. These cranes are normally powered by McLaren type M Mark II diesel engines, but alternative power units may be fitted when specified.

SPECTROGRAPH WITH THREE MEASURING HEADS

A triple medium spectrograph for metallurgical analysis has been added to the range of instruments made by Hilger and Watts Limited, 98 St. Pancras Way, Camden Road, London, N.W.1. The new instrument, it is claimed, will do all the work for which two instruments have hitherto been required. It is a photographic and direct-reading spectrograph combined and will therefore be of particular use in laboratories where there is a large amount of routine work to be done, but where there are also some qualitative and quantitative analyses that fall outside the scope of the direct-reader.

As its name implies, it has three measuring heads. One of these is for photographic analysis and can be used for the same type of work as the well-known Hilger medium quartz spectrograph. The other two measuring heads can be set up for the automatic analysis of non-ferrous metals, oils, soil, and similar materials. The spectrum required is chosen by switching mirrors.

Each direct-reading head accommodates 12 photomultipliers and will give quantitative analysis of up to 11 elements in about 2 minutes. These direct-reading heads can be set up for two completely different analyses (e.g., aluminium and magnesium alloys) or for the analysis of two different groups of elements in the same alloy (e.g., minor constituents and trace elements). For the latter application it is normal to use two separate sparkings—one for the minor elements using one bank of photomultipliers, and the other for trace elements using the other bank of photomultipliers; though in certain restricted circumstances it is possible to analyse up to 22 elements with one sparking.

It is not necessary to buy both direct-reading heads at the same time. The instrument can be supplied in the first place with only one of these attachments and the second can be fitted at a later date, when required.

Production

WELDING, FLAME CUTTING AND FABRICATION

Below, we give further brief extracts from five of the papers presented at the Conference on Technology of Engineering Manufacture, arranged by the Institution of Mechanical Engineers and held in London from 25 to 27 March. The first paper, by Mr. C. A. Burton, of Sciaky Electric Welding Machines Limited, is entitled "Modern Developments in Resistance Welding."; the second, by Dr. Nicol Gross, of Quasi-Arc Limited, describes "Modern Developments in Arc Welding"; the third, by Mr. G. Sims-Davies, of British Oxygen Gases Limited, deals with "Flame Cutting"; the fourth, by Mr. R. M. Watts, of Metropolitan-Vickers Electrical Company Limited, is concerned with "Fabrication Practice for Machine Elements," and the fifth, by Mr. A. H. Goodger, of the National Boiler Insurance Company, Limited, Manchester, relates to "Weld Inspection."

RESISTANCE WELDING

Progress in the development of all resistance-welding processes has been so rapid during the past few years that most branches of engineering industry have undoubtedly benefited from the installation of special-purpose welding plant which in some instances can be considered as the introduction of partial automation and in several cases, complete automation.

Large motor-car manufacturers in America and in Great Britain are now making use of multiple transformer-die sets mounted in large mechanical presses. One of the most recent and outstanding developments in welding in the motor-car industry, is the spot-welded wheel. Practically all present-day motor-car wheels are of the steel disc type, consisting of a channel-shaped drop-centre steel rim mounted on a circular flanged disc. Each welding cycle consists of three steps, namely, squeeze time, heating time and holding time, and all these functions are adequately controlled by means of an electronic system.

Spot welding is also increasingly used in the aircraft and railway rolling-stock building industries, while an installation capable of spot welding very heavy girder structures having plate thicknesses of 0·55 and 1·25 in is now in being. A typical beam which has been made has a length of nearly 70 ft, and forms part of an assembly 132 ft long and weighing 45 tons.

ARC WELDING

The main process applied in engineering manufacture is still arc welding in its manual form. A constant development effort, resulting in novel types of electrodes with features valuable in production, in conjunction with some advances in power sources, have continued to ensure for manual welding over 90 per cent of all arc-welded steel applications.

Thus, electrodes having heavy coverings containing a high proportion of iron powder and an electrode with a rutile covering containing iron powder have been introduced. A notable development in power source is to be found in the direct-current field, where the metal-plate rectifier has demonstrated in service its advantages over rotary equipment.

Welding has to keep pace with the increasingly heavy demands of the new industries, such as nuclear power engineering. These demands are characterised by the development of new alloys and sometimes by the use of very heavy plate.

FLAME CUTTING

Apart from the normal hand applications of the flame-cutting oxy-acetylene or oxy-propane blowpipe, and the static and cross-carriage cutting machines, the technique of oxygen lancing for cutting holes in thick steel plate or concrete blocks has progressed of late. Furthermore, hot cropping machines for cutting up blooms, slabs and bars, and hot deseaming machines for "skinning" the surface of all four sides of hot slabs or blooms are now used in the steel industry. In the field of steel plate preparation by the flame-cutting process, a system has been devised whereby the control of the cutting torch or torches is by means of magnetic tape. (This, a computer-controlled flame-cutting machine, was described and illustrated on page 774 of our issue of December 20, 1957.)

FABRICATION OF MACHINE ELEMENTS

Welded fabrications have supplemented castings for many of the elements required for the manufacture of items such as water, steam and gas turbines; turbo and water-wheel alternators; transformers and switchgear; instruments and meters; industrial mining and traction control gear; motors; railway signals; heating and welding equipment; electronic equipment and scientific apparatus.

The layout and organisation of a fabrication department must be very flexible and capable of rapid modifications to meet variations in the demand for any product. It is reasonably easy to plan a shop for one product but the layout of a jobbing shop requires compromise and vision. The layout of such a shop comprises a plate stockyard where plate material received either by rail or road transport is stored. Standard-size plates are stored horizontally; this both protects the plate from oxidation and makes lifting by magnets possible. Oversize plates and those ordered against particular contracts are stored in "toast racks." A 13 ton diesel rail crane with a 30 ft jib services the area.

Bars and sections are stored in a separate stockyard and from there they are either cropped or flame-cut and then conveyed to a steel-preparation shop for forming or rolling. The items thus produced in these two sections, together with pre-machined parts and cropped and forged items, are conveyed to various stores situated on both sides of the main department and, when the whole "kit of parts," required for a fabrication, is complete, it is sent to the assembly shops for completion. An efficient production system ensures that all "bits and pieces" are available at a given time, thereby reducing delays during assembly.

WELD INSPECTION

Welding is probably at its greatest stage of development, and the inspection of welding is also used to a greater extent than ever before. Inspection is a difficult art and it is seldom that one test or method of inspection will give all the information required. Unfortunately, much inspection is conducted without real knowledge regarding the underlying reasons why it should be done. From observation of numerous cases, it is obvious that many persons inspect welds without asking the question: "Why am I inspecting this part and what will be the significance of a defect if I find one?" The answer to such questions can be given at the present time only by an inspecting engineer of long experience and personal knowledge and this is likely to remain true for some time. It is essential for an inspecting engineer to have a knowledge of the mechanisms of failure as well as some understanding of the basis of design. It is likely that the amount of inspection needed will diminish as welders become better qualified, as the knowledge regarding the influence of "stress raisers" is increased, and when designs are based on a more scientific foundation.

Continuing **Production**

FOOD FOR THE SOIL

Factory for Concentrated Complete Fertiliser

Since it had become evident that nothing short of rebuilding could transform the many small plants comprising the fertiliser works of Scottish Agricultural Industries Limited into an economic concern, a full appraisal of the situation was made. As a result it was decided that the type of fertiliser to be made was the concentrated complete form (CCF) to be produced as a granular free-running material which would not cake during storage. As a site for the new plant the company leased 19 acres of land at Leith docks that the Commission were reclaiming from the sea. At the same time arrangements were made for the use of a berth in the Imperial Dock for incoming vessels (75 per cent of the raw materials have to be imported) and the extraction of cooling water for the various processes. Three grades of fertiliser are made with varying ratios of nitrogen, phosphorus pentoxide and potash.

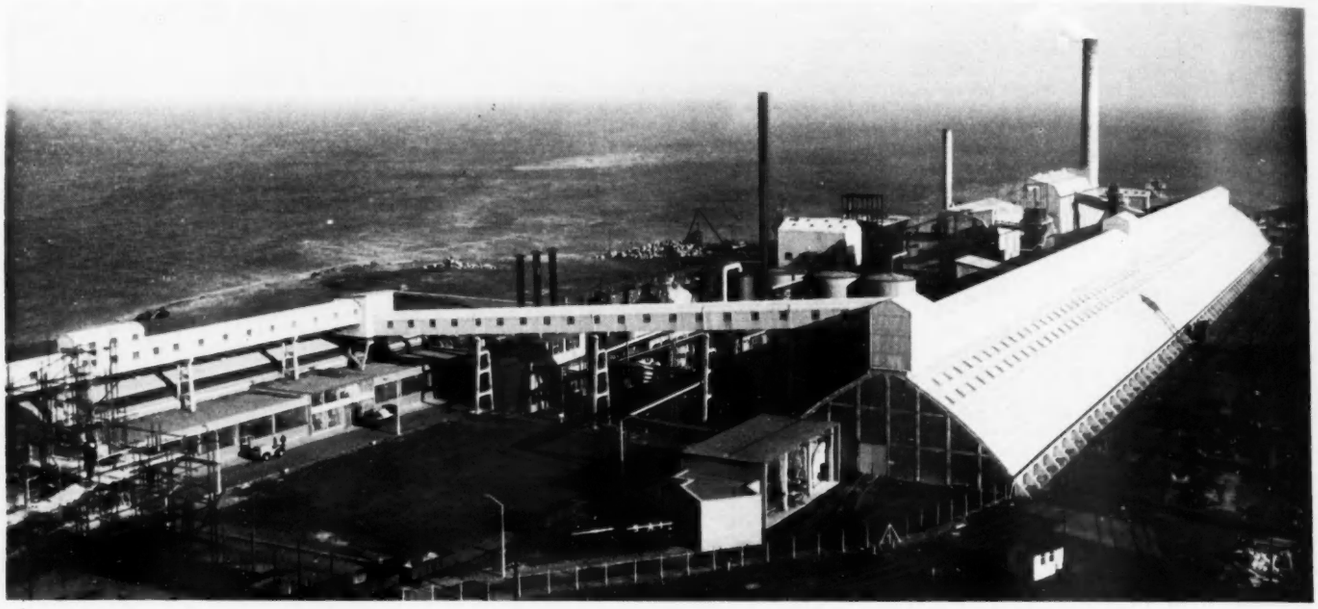


Fig. 1 The new S.A.I. fertiliser factory is built on reclaimed land. On the left is the conveyor for incoming raw materials, on the right the main store. The furthest chimney marks the last stage of production.

The five raw materials involved are sulphur, phosphate rock, muriate of potash, ammonium sulphate, and ammonia. They are passed through four main processes, the production of sulphuric acid from the sulphur; the production of phosphoric acid from the sulphuric acid and the phosphate rock; the neutralising of the phosphoric acid by ammonia to form ammonium phosphate; and finally the mixing of this with ammonium sulphate and muriate of potash to give a granular product of the right proportions. The final product will not be stored at the dockside works but at a new building in Salamander Street, Leith, to which it will be taken in covered rail wagons. The bulk capacity of this store, which will act as buffer to cover seasonal fluctuations in sales, will be about 40,000 tons.

HANDLING

Material arriving by sea will be unloaded by grabbing cranes into movable hoppers that can be positioned to suit the ship. These in turn feed short conveyors that take the material to a cross conveyor running underground along the side of the quay. An underground conveyor was used here so that the surface should be left clear as it belonged to the Dock Commission. A series of manholes, which can be sealed during discharge to prevent the spread of dust, give access to the conveyor. A rising conveyor leads to the main gantry, half of which can be seen in Fig. 1 on the extreme left. This section of the conveyor system is 771 ft long and has a Blake Denison continuous belt weigher about half way along it. The total length of the conveyor system is 1,470 ft. The belts are 36 in wide and the capacity is 350 tons per hour.

Above the main store, which is 900 ft long, runs another conveyor for half the length and below it a shuttle conveyor 431 ft long for delivering the material to the appropriate section. Reclamation is by mechanical shovels, and tests are being made of an electrically propelled machine drawing its supply through a cable hanging from the roof. The object is the reduction of fumes within the building. Facilities have also been provided for material to be brought by road and rail—a dumping grating is provided for lorries and a tippler for wagons. In each case the materials are lifted by elevators and conveyed across to the main store. To ease the handling of rail wagons within the site, the track has been laid on a gradient of 1 in 200, which is sufficient for the wagons to be moved by the use of a pinch bar.

SULPHURIC ACID

The sulphuric acid is produced by the Monsanto contact process in a Simon-Carves plant with a capacity of 175 tons per day. The flow diagram is shown in Fig. 2. Sulphur from the store is melted in a brick-lined steam heated pit and over-flows into a storage tank. From this it is pumped through a Kelly pressure filter to a second tank, the filter being capable of removing ash down to a level of 0·05 per cent together with some of the bitumen present in the darker grades. The resultant cleaned molten sulphur is pumped through steam-lagged pipes to the burner where it is burnt with dried preheated air to give about 7·5 per cent of sulphur dioxide. Heat produced by the combustion is used in a waste heat boiler, with elements of Foster-Wheeler type, to generate steam to provide the motive power for the turbo-blower that forces the gases through the plant and also for a turbo-generator of 300 kW output. These are both pass-out units and the low-pressure steam from them is normally sufficient for the factory demand for both heating and process use. Space has been left for plant to handle pyrites should the supply of sulphur present any difficulties.

The combustion gases are filtered, and then the SO_2 is converted to SO_3 by passage over four catalyst beds in a single tower. This again is an exothermic reaction and the heat evolved during the successive stages is used to preheat the air for the combustion chamber, in the boiler superheater and in the economiser. The second stage is cooled by the addition of cold air. The SO_3 is cooled to a controlled temperature and then absorbed in 98·5 per cent sulphuric acid in the usual way. The acid is cooled by sea water and rediluted to its original strength. Cast-iron pipes are used throughout for the acid and three welded mild steel tanks give storage for 3,900 tons. As many as possible of the controls for the process are grouped in a central room, including the controls for the sulphur pumps.

PHOSPHORIC ACID

The wet process is used for the manufacture of the phosphoric acid, the materials being sulphuric acid and powdered phosphate rock and the second product gypsum. Fig. 3 shows the operation. Very exact control of the reaction is required in order to yield a crystal gypsum that can readily be filtered and washed. The plant is of the Prayon type designed by the Engineering and Industrial Corporation of Luxembourg. The phosphate rock is fed to an air-swept Bradley Poitte mill through a Simon weigh belt feeder by which the supply can be regulated. The powdered rock is transferred to the reaction stage by a Fuller-Kenyon pump. The reaction vessels are steel, lined with rubber and carbon brick as the magma contains a mixture of sulphuric acid, phosphoric acid and traces of

hydrofluoric and hydrochloric acids and is therefore extremely corrosive. From the last compartment of the vessel a proportion of the magma is pumped to the Prayon filter, an important item in the plant.

The Prayon filter consists of eighteen trays carried on radial arms which rotate slowly in a horizontal plane. The trays are of stainless steel with cloth floors backed by perforated rubber. Each empty tray passes in turn under the magma supply head and is filled. The acid is drawn off under vacuum applied (through the radial arms) to the underside of the tray. The tray then passes successively under washes of strong acid, weak acid and water, time being allowed between each for all the liquid to be sucked off. The washing liquors are recycled, eventually working back to the attacking section in the reaction vessels. After the last wash the tray is inverted and the gypsum collected in a hopper from which a screw makes it into a slurry with sea water and passes it into the main outfall drain. As on the sulphuric acid plant, all the controls have been grouped in one room.

FINAL PRODUCT

The last stage of the production consists of two operations, the concentration and neutralisation of the phosphoric acid and the final mixing and granulation of the materials. These are shown diagrammatically in Fig. 4. The plant used was designed by Dorr-Oliver Incorporated and constructed by Simon-Carves.

Concentration is carried out by steam evaporation in a Svenson plant with the acid being continually recirculated as it contains some solid matter which might precipitate out in the chambers. A measured flow of the concentrated acid is fed to the neutralising chambers.

The ammonia used is obtained either from synthetic liquor or from by-product liquors from coal distillation plants—liquors which are frequently run to waste for lack of an economic means of recovery. At Leith the apparatus was designed by the Coppee Company Limited and is almost completely automatic in operation. The reaction, which is highly exothermic, produces a slurry containing ammonium phosphate, ammonium sulphate and impurities such as iron and aluminium phosphates and fluosilicates. The heat evolved is used to dry the

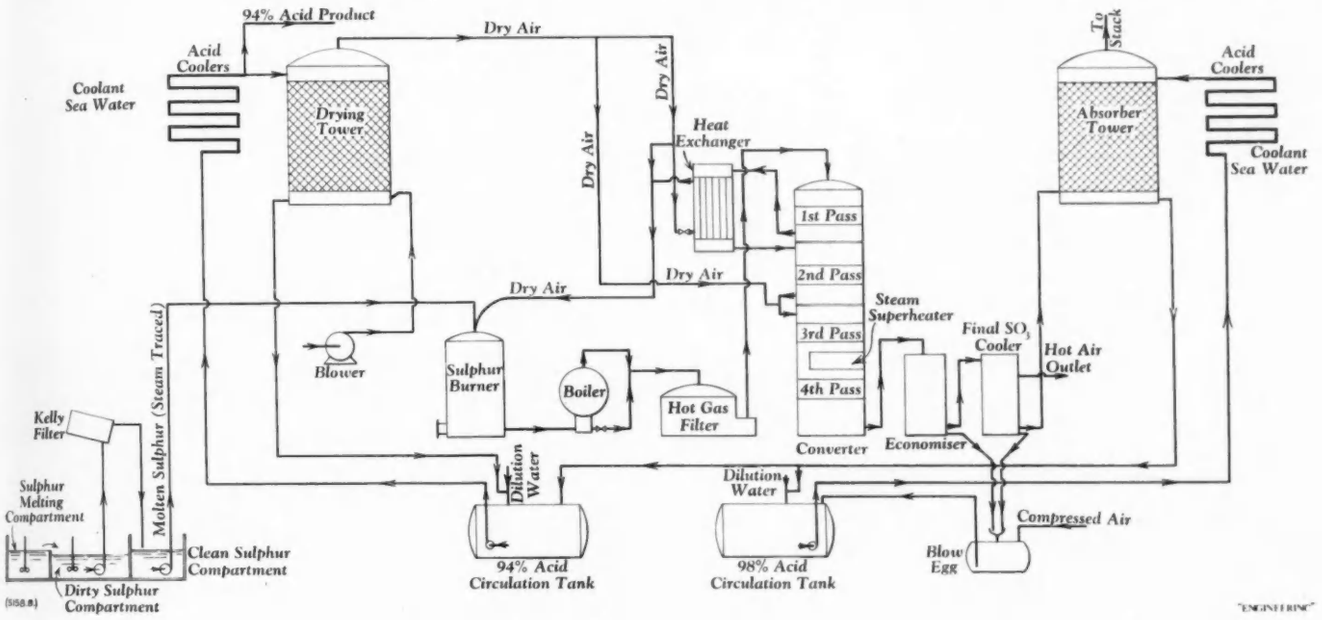


Fig. 2 The first stage is the formation of sulphuric acid by the combustion of sulphur. The waste heat is used to generate power and steam for heating and process use.

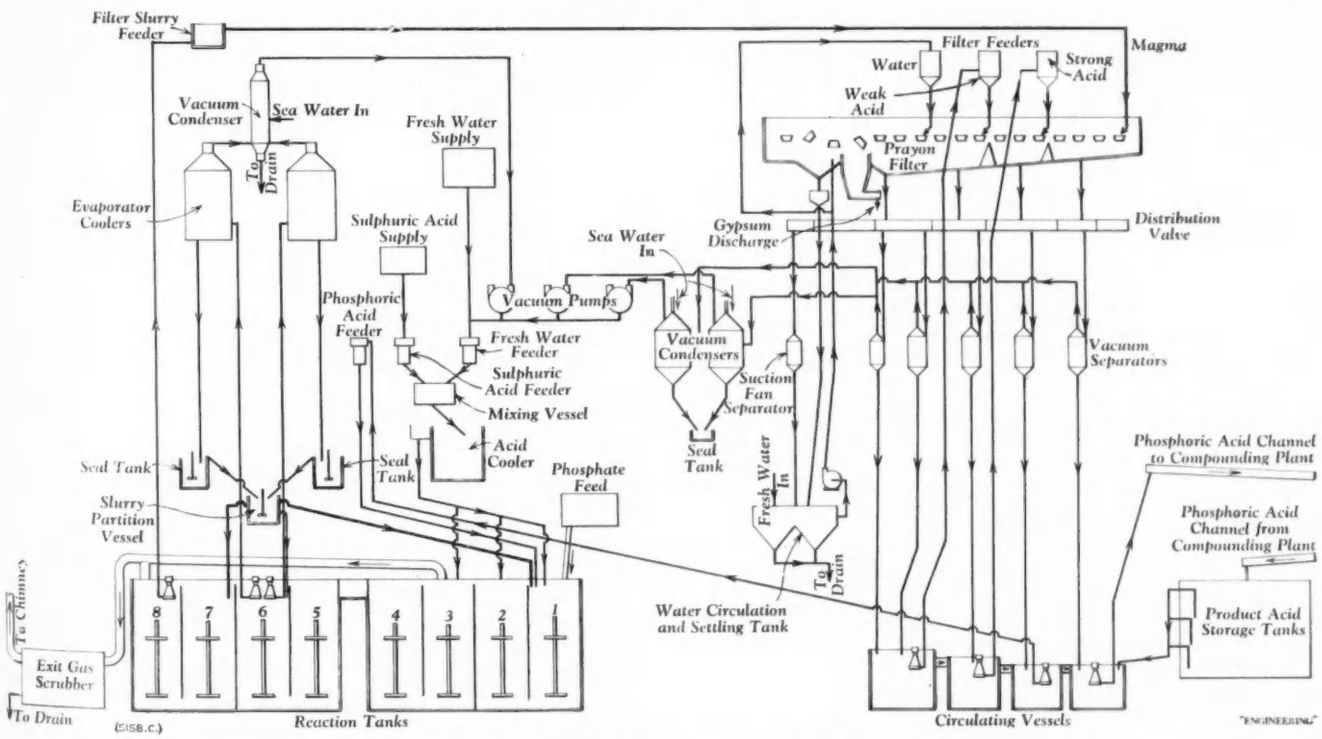
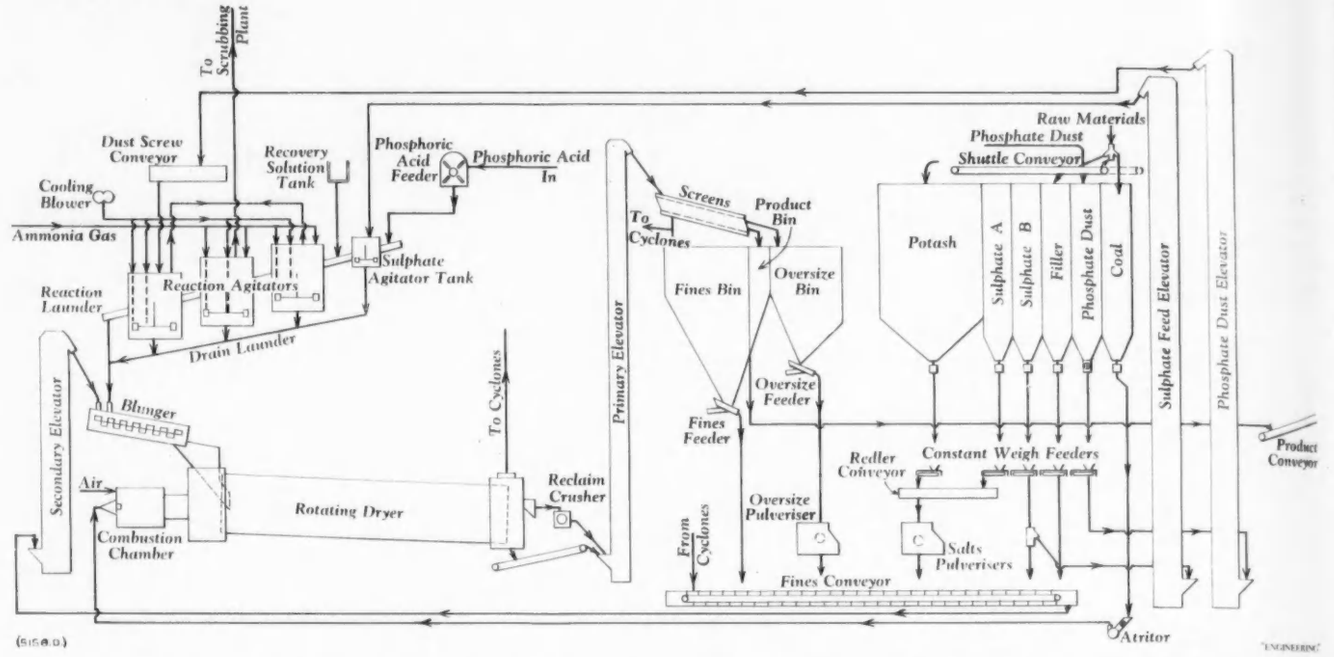


Fig. 3 Phosphoric acid is formed in the second stage from sulphuric acid and phosphate rock.

Continuing Production



mixture to the degree needed to keep the load on the dryer down to a minimum. To bring the concentrations to the required figure, solid sulphate of ammonia and muriate of potash have to be added at this point. As the mixture is still too wet to granulate properly some of the final product, consisting of fines and oversize material that has been crushed, is recirculated and mixed with the new preparation. The whole then enters the " blunger."

The blunger consists essentially of a twin shaft mixing trough which forms a granular product with a moisture content of about 5 per cent. Final drying is carried out in a rotary co-current kiln fired with pulverised coal. The kiln is 11 ft in diameter and 93 ft long; the air flow through it is between 40,000 and 50,000 cu. ft per min. Screens divide the fertiliser above and below 3 mm and 1·5 mm respectively. Over- and under-size particles are recirculated as mentioned earlier, and the selected product is weighed and bagged or loaded into bulk transport for storage at Salamander Street. The gas effluent from the dryer is cleaned in Doyle scrubbers, capable of dealing with 75,000 cu. ft per min, before being discharged to atmosphere through the 200 ft chimney.

Fig. 4 (above) In the third building, the phosphoric acid is neutralised by ammonia gas, and the resulting ammonium phosphate mixed with potash and ammonium sulphate, granulate and dried to give a free-running product.

Fig. 5 (right) Concrete is extensively used on the site, as in the main store, built on the three-pin arch principle, which is 900 ft. long and 100 ft wide at the base.

SERVICES AND CONSTRUCTION

Since many of the processes are exothermic, the operation of the plant is normally independent of outside supplies of steam but some electricity is needed. However, since a steam failure could be disastrous, three Cochran vertical boilers have been installed. Two of these are hand controlled but the third has automatic firing and moreover is connected permanently to the steam supply, acting as a reservoir so that in an emergency it can be started up immediately.

The two main by-products are gypsum and ammonium phosphate. At present the former is discharged to sea as waste but a plant is being erected to convert the latter to mon-ammonium phosphate, for which there is a large demand as a fireproofing material. Throughout the whole works the principles of economy by integration have been strictly observed. It is expected that output will be 150,000 tons of fertiliser a year.

In view of the corrosive nature of much of the material handled, the construction of the plant required careful forethought. Concrete has been used extensively, and in the process vessels stainless steel and rubber linings were needed in many places. The main store for the dry constituents (Fig. 5) is of reinforced concrete with prestressing along the length. It is 900 ft long and 100 ft wide at the base rising to 60 ft at the top of the conveyor housing. Three-pin arch construction has been adopted, each of the two members being 75 ft long and resting in place by their weight only. At the crest one surface is convex and the other concave, while between them is a strip of Balata belting to spread the load over any high spots. Similar strips are placed between the surfaces of the junctions of the arch members and the side wall buttresses. Duplicate arches are placed every 150 ft to allow for expansion, and each of the sections is separately stressed longitudinally, the stressing wires passing through tubes cast in the members. The cladding is asbestos sheeting.

The inner wall is built on the old sea-wall and so did not need any piling, but the outer wall on the newly reclaimed land is on piles. Both walls are 6 ft high. The floor is a cast slab, not on piles as it was thought to be cheaper to replace it in the event of sinking than to drive enough piles to carry it. Internally, the store is divided into sections for the different materials by Stelcon cast-concrete movable bulkhead sections with a screen above them to prevent contamination of the materials. Material arriving is first directed from the conveyor down a fixed chute to prevent unnecessary dust until the stock pile is high enough for direct addition from one of the numerous manholes in the roof. The capacity of the store is about 56,000 tons.

For storing the ammoniacal liquors the tanks are made of concrete prestressed by circumferential wires following the Preload system. The walls are 4 in thick and stand on prestressed bases. The initial loading in the binding wires was 140,000 lb per sq. in, which fell to about 100,000 lb per sq. in as the material contracted.

Another item that is subject to corrosion is the main effluent drain. This has been constructed in the form of an inverted V-channel on land feeding into a cast-iron pipe where it enters the water. The channel has been lined with polythene sheeting against which the concrete was cast, and patent tiles set in latex have been used on the sides. The cast-iron pipe has not been lined. An unexpected (and unusual) hazard encountered in driving the piles for the pipe was the wreck of a multi-deck wooden ship which necessitated a change in direction.

The conveyor gantry is of tubular steel construction measuring about 9 ft 6 in by 11 ft 6 in and carried on reinforced concrete trestles 40 ft high and 75 ft apart. It was prefabricated in 15 sections and brought to the site for erection. As on the main store, asbestos cladding has been used with plastics windows.

Consultants for the civil engineering work were Kinnear and Gordon of Edinburgh and the architects were Basil Spence and Partners. The main contractors for the civil engineering work were W. and J. R. Watson Limited and J. White (Contractors) Limited, both of Edinburgh.

COLLIERY PLANT FOR COKE AND CHEMICALS

A MAJOR reconstruction and development scheme by the National Coal Board at Manvers Main Colliery coke ovens has been completed, and the plant, situated at Wath-on-Dearne, near Rotherham, is now the largest in Great Britain. Simon-Carves Limited, Stockport, were the principal contractors.

Occupying a site of 90 acres, the plant has 137 coke ovens, complete with by-product recovery equipment, boiler house and power station, and is designed to carbonise one million tons of coal a year. It will produce 650,000 tons of coke, 50,000 tons of crude tar, 8,500 tons of sulphate of ammonia, 4,000 tons of concentrated ammonia liquor, and 3½ million gallons of crude benzole. Daily production of gas for sale to the East Midlands Gas Board is 19½ million cu. ft. Both metallurgical and domestic coke are produced, and the plant is so arranged that the two types of coke can be made, stocked and handled separately; proportions being varied as needed.

Coke ovens associated with Manvers Main Colliery have existed for many years, and when the Coal Board took over there were 45 ovens on the site, in two batteries of 15 and 30. These two batteries, though not unduly old, had suffered as a result of war conditions, and they were therefore rebuilt. This was done in stages, in order to maintain gas supplies, the first stage being the building of 17 new Simon-Carves compound ovens. The 15-oven battery was then rebuilt, and finally, the 30-oven battery was remodelled as two blocks of 13 and 14 ovens respectively, only the block of 13 being put in hand at first. Rebuilding ended in 1953.

Colliery developments planned during the rebuilding of the ovens called for a central coal preparation plant at Manvers Main, to deal with the output from four collieries, Manvers, Wath, Kilnhurst and Barnburgh; coal from the first three being wound at Manvers and that from the last-named being brought overland. As the estimated output of saleable coal from the preparation plant was 12,000 tons a day, with a large tonnage of coking smalls, and as the site was suitably placed in respect of the gas grid, it was decided to increase the carbonising capacity at Manvers to 3,000 tons a day.

Very detailed planning was necessary, as the site is restricted, and is cut into four by two lines of British Railways, a public road had to be diverted, and it was necessary at all times to maintain continuity of gas supplies to the grid.

OVENS ON TWO SITES

Only limited extensions were possible on the existing oven site, and a new site nearby was therefore chosen for the erection of a battery of 66 ovens. On the old site, besides the 17 new compound ovens and the rebuilt blocks of 15 and 13, the final 14 ovens of the old 30-oven battery were rebuilt, and an additional block of 12 new compound ovens was added. All the ovens are to the same dimensions—length over oven sole 38 ft 6 in, chamber height 13 ft 3 in, and mean width 1 ft 6 in; the weight of the charge being 14 tons. The throughput is now about 1,320 tons a day. A new set of charging and pushing equipment has been added to the existing machines on the old site, and a new chimney serves all the 71 ovens; the old chimney was demolished to make room for a spare ram.

On the new site, the battery of 66 ovens was built in two blocks of 33. As no size restrictions were imposed by existing oven machinery, larger dimensions were chosen for these ovens, which have a length of 44 ft 7 in over the sole, a chamber height of 14 ft 9in, and a mean width of 1 ft 5¾ in. The charge weight is 17·8 tons, and the throughput 1,570 tons a day.

Several unusual features have been incorporated in the design of the new battery. To save ground space the ram track is carried on a steel structure about 19 ft above ground level, and the space below is used for locker, shower and mess rooms, workshops, and an electric substation. There are two complete sets of oven machinery. "Microsen" gear on the ram machine travel motors enables these machines to be centred quickly and smoothly. In case of power failure the ram can be moved at reduced speed by a compressed-air motor. The charger cars are of the usual portal frame type, but are equipped with special suspension gear, being carried on bogies riveted to the chassis frame on one side and mounted in pin bearings with hydraulic dampers on the other side. The three-point suspension thus provided evens out the load and prevents "crabbing" and vibration. Wear and tear on the oven top brickwork are greatly reduced by the practical absence of vibration. A measure of the success of the suspension is provided by the silence of operation, which is such that special warning bells, sounding at the first movement of the travel controller, are fitted in place of the usual mechanically-operated bells.

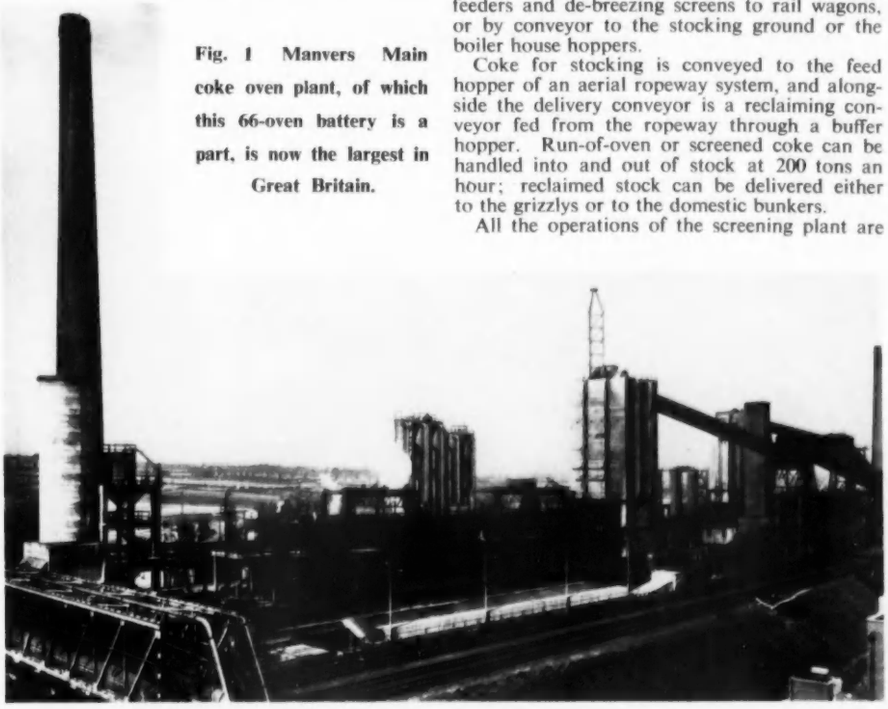


Fig. 1 Manvers Main coke oven plant, of which this 66-oven battery is a part, is now the largest in Great Britain.

All the oven machines operate on a 110 V 3-phase a.c. supply, which reduces greatly the danger to personnel from the trolley wires. This current supply has also been used for the new machines on the old site, and the old ram machine, which formerly used direct current, has been converted.

Self-sealing oven doors are fitted throughout the plant, the new battery and three of the batteries on the old site having a new type of latch gear. This gear gives a constant closing force, and the door is tightened on to its seating by its own weight instead of the conventional rose and screw. Two toggle arms pivoted to the door body engage with the latch hooks, and the weight of the door acting through the toggle arms forces the sealing strip on to its seating. To remove the door the extractor head takes the weight in the usual manner, and the toggle arms are then raised until the latch bars are clear of the hooks, by hand wheel operation of a screw jack in the linkage between the arms; the door is then withdrawn.

COKE HANDLING

Separate conveyors lead from the old and new sites to the coke screen house, crossing the main railway line on the way. Each conveyor feeds its own line of grizzly screens, and the oversize product from these screens can either be delivered by boom loader to railway wagons, or to the adjacent stocking ground. Through products (under 2½ in) may be fed either to secondary screens or to stock. A proportioning device enables some or all of the run-of-oven coke to by-pass the grizzlys, and to be fed through a cutter to the secondary screens or to the stocking ground.

The secondary screens are fed from a hopper distributing to three double-deck vibrating screens, the "throughs" of which are conveyed to a further stage, comprising three more double-deck screens. Graded coke is conveyed to domestic bunkers with five 30-ton compartments, for coke breeze and four sizes of nuts. From here graded coke is delivered by vibrating feeders and de-breezing screens to rail wagons, or by conveyor to the stocking ground or the boiler house hoppers.

Coke for stocking is conveyed to the feed hopper of an aerial ropeway system, and alongside the delivery conveyor is a reclaiming conveyor fed from the ropeway through a buffer hopper. Run-of-oven or screened coke can be handled into and out of stock at 200 tons an hour; reclaimed stock can be delivered either to the grizzlys or to the domestic bunkers.

All the operations of the screening plant are controlled from a push-button desk, and a mimic panel in the control room shows the whole of the coke handling and screening plant in diagram form, with indicator lights to show the actual flow of coke. The coke plant sidings are integrated with those of the washery to simplify road transport.

BY-PRODUCTS

A by-product plant consisting of primary condensers, exhausters, de-tarrer, ammonia scrubbers and benzole scrubbers existed to serve the old site, and this has been retained to work in conjunction with new equipment housed on the new site. This new plant handles the gas from the new 66-oven battery, and from the rebuilt batteries of 13 and 14 ovens on the old site. The new plant thus receives the gas from carbonisation of about 2,000 tons of coal a day, leaving the old plant to handle a slightly lower gas volume than before. Gas for oven heating at the old site is taken from the outlet of the benzole scrubbers via two Askania governors. Surplus gas enters the outlet main of the new by-product plant. Liquor from the ammonia scrubbers is worked up in a concentrated ammonia liquor plant on the new site.

The new by-product plant comprises primary condensers, exhausters, de-tarrers, semi-direct saturators, direct secondary coolers and benzole scrubbers. At the point where gas from the old site is received an existing gasholder is con-

Continuing Production

nected to the main to act as a balance. The main divides into two, one branch delivering heating gas to the 66-oven battery via an Askania governor, while the other passes surplus gas to the final naphthalene washers. From the outlet of these washers the gas flow is again divided, about four million cu. ft a day being pumped unpurified to Swinton and Mexborough for the Gas Board, while the remainder is boosted through tower purifiers and returned to the compressors which deliver to the gas grid. A 750,000 cu. ft gasholder acts as a balancer on the purifier outlet. Provision is made for the dilution of all surplus gas by producer gas, but the producers are not yet installed. There are five vertical water-tube condensers (one spare) working in parallel, with provision for a sixth, and two turbo-exhausters (one spare) driven by back-pressure steam turbines. The de-tarrers are of standard Simon-Carves tube type, with riveted shells. From the de-tarrers the gas passes to two saturators, one of which is spare; salt from the saturators is elevated to a settling cone feeding either of two centrifuges and thence to a drier from which it is elevated to a hopper in the salt store. From this point the dried salt can be bagged, or loaded by belt to wagons or to stock.

Gas from the saturators enters the direct secondary cooling towers of which there are two in series, a naphthalene washing section being included. Cooled gas passes to three benzole scrubbers in series.

The concentrated ammonia liquor plant, which is on the new site, also handles the liquor from the ammonia scrubbers on the old by-product plant, and includes the still for the liquor from the new plant. A vapour line carries the still vapours to the gas main at the inlet to the saturators. Both stills are served by a single liming plant.

The gas-handling equipment on the outlet of the benzole scrubbers is common to both by-product plants, and the heating gas for the batteries is taken from this main, to which the balance holder is connected. A connection is also taken to a gas bleeder mounted on the service bunker of the 66-oven battery. Surplus gas passes to two static ring-packed naphthalene washers in parallel; these have six washing chambers, with corresponding circulating pumps. The washing medium is gas oil, which is regenerated in a plant adjoining the washers. The dilution gas main will be connected to the outlet of the naphthalene washers, and provision is made for automatic regulation of the calorific value of the diluted gas.

Two gas blowers (one spare) driven by flame-proof motors, pass the greater part of the gas from the naphthalene washers to six Holmes tower purifiers using iron oxide, this installation being complete with charging and discharging apparatus and plant for making up and storing fresh oxide charges.

On the outlet of the purifiers is a connection to a 750,000 cu. ft gasholder which provides a balance on the inlet to the compressors. Purified gas passes via a Connersville gas meter to the compressors feeding the gas grid. There are four compressors, each with a capacity of six million cu. ft a day, and space is available for two more machines. One of the compressors is electrically driven, one is steam driven, and two have dual drives, the motors being housed in a separate room and coupled through gas-tight glands in the wall. This driving arrangement enables varying gas loads to be handled with the greatest possible economy of steam and electricity.

Unpurified gas for the public mains is taken off the inlet to the purifier boosters and passed through its own Connersville meter to either of two compressors of four million cu. ft a day capacity, one compressor being motor driven while the other has dual drive. Two indirect after-coolers are provided.

BENZOLE REFINING

The Manvers Main benzole refinery is designed to take not only the Manvers output, but also to deal with a quantity of crude spirit brought from other N.C.B. works in the district. Crude benzole from the whole plant is recovered in three stills located on the old site with their oil heaters, columns, coolers and naphthalene trays. Units from the old plant have been transferred to the new refinery, and the space thus freed has been used for the stills, heaters and coolers. The crude spirit is pumped to storage tanks in the new refinery.

Daily capacity at the refinery is 15,000 gallons of crude spirit, which represents the whole output from Manvers, together with a million gallons a year from other works. The plant, (including the units from the old site) comprises two defronting columns, six batch stills, each with its own fractionating column, and three washers. There is also an acid regeneration plant, and the refinery is fully self-contained with its own built-in fire fighting equipment, offices, laboratory, workshop, welfare building, and cooling water circuit.

The process steam supply is arranged for maximum economy. Steam at 140 to 150 lb per sq. in, and 500° F is received from the back-pressure turbines in the power house and passes through a de-superheater before entering the heating coils of the stills. Low-pressure steam at 15 lb per sq. in is derived from the exhausts of the reflux and circulating pumps on the plant, and used as direct steam in the defronting columns and acid regeneration plant. It is also used in a special heater which heats the condensate used in the anti-freeze coils in the pure benzene tanks. Any surplus condensate is added to the clean water circulating system which supplies the condensers via a water cooling tower.

Crude benzole is defronted, washed with once-used acid, and then distilled in the primary stills, which produce either motor spirit or semi-pure products. Motor spirit is run to storage tanks, and semi-pure products are washed again with strong acid before re-distillation in the secondary stills. All storage tanks are mounted inside bund walls, and permanent foam lines run from the fire pump house to the various units. The columns work on the pumped reflux system, and are designed to make a wide range of products. Three grades of pure benzene of different specifications are normally made, together with toluene, xylene and solvent naphthas.

STEAM AND POWER GENERATION

The electric power plant runs in parallel with the mains of the Yorkshire Electricity Board, and power can be fed into or drawn from the mains according to circumstances. Two Parsons back-pressure turbo-alternators generate current for use in the plant and pass out steam for process work and other purposes. Steam is raised in three Simon-Carves tri-drum twin-circulation type boilers, which are arranged for firing by coal and coke oven breeze, by coal, or by coke oven gas. Provision is made for future firing by coal and tar fuel. Each boiler is equipped with water-wall combustion chambers, superheater and economiser. Firing is by a single-grate mechanical stoker, and two gas burners in each side wall. The steaming conditions are: steam pressure, 625 lb per sq. in; steam temperature, 815° F; feed water temperature at economiser inlet, 220° F; continuous maximum rating, 60,000 lb per hour; continuous peak load, 70,000 lb per hour.

Two steam reducing valves are provided, to reduce the pressure from 650 to 160 lb per sq. in, and two spray type de-superheaters reduce the steam at 160 lb per sq. in to a temperature of 550° F; this equipment maintains the steam supply to the plant when the turbo-alternators are shut down. The power station building also houses the main 550 V switchboard, and there is a water treatment plant adjacent, which supplies water for the boilers and other plant.

Fig. 2 (left) A complete boiler and electric power unit provides all the steam requirements of the plant, in addition to electric current.

Fig. 3 (above) Benzole refining is carried out for other N.C.B. works as well as for Manvers. The benzole refinery is large and self-contained.

★ ★ ★

INDIAN BLAST FURNACES

Towards the end of 1954 a contract for two large blast furnaces at Burnpur, India, amounting in value to nearly £3 million, was placed with Ashmore, Benson, Pease and Company, Stockton-on-Tees, by the Indian Iron and Steel Company, Limited.

The first of these two furnaces went into operation on January 30, over two months ahead of schedule, and this furnace, the largest so far in operation in India, has a rated capacity of 1,200 tons of iron a day. The second blast furnace is planned to go into operation in the autumn of the present year. The consulting engineers, are International Construction Company, Limited, 56 Kingsway, London, W.C.2.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
Discussion on "Maintenance and Installation Problems." Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Mon., 21 April, 6.30 p.m.

CROYDON
"Earth Leakage Protection of Domestic and Industrial Installations," by J. A. Robbins. South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 24 April, 8 p.m.

British Computer Society

LONDON
"Use of an Electronic Computer in Research Statistics: Four Years' Experience," by Dr. Frank Yates. Caxton Hall, off Victoria Street, S.W.1. Mon., 21 April, 6.15 p.m.

British Institution of Radio Engineers

LONDON
"Measurement of the Frequency Response of a Nuclear Reactor," by R. J. Cox, D. Harrison and R. B. Stevens. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Wed., 23 April, 6.30 p.m.*

CHELTENHAM
"The Automatic Factory," by J. A. Sargrove. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri., 25 April, 7 p.m.

Building Centre

LONDON
Films on "Harvesting of Hardwoods in Nigeria," exhibited by Unilever Ltd. Wed., 23 April, 12.45 p.m.

Chemical Society

BRISTOL
"Water-Repellency," by Professor N. K. Adam. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., 24 April, 5.15 p.m.

CAMBRIDGE
"Recent Applications of Raman Spectroscopy," by Dr. L. A. Woodward. Cambridge Branch. University Chemical Laboratory, Lensfield Road, Cambridge. Mon., 21 April, 5 p.m.

PORTSMOUTH
"Naturally-Occurring Acetylenes," by Professor E. R. H. Jones. Southampton Branch. College of Technology, Portsmouth. Wed., 23 April, 7 p.m.

Combustion Engineering Association

BIRMINGHAM
Films on conveyors shown by W. G. Picton, at 10.30 a.m. "Industrial Use of Coke," by E. Murphy and A. S. Boyle, at 2.30 p.m. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham 2. Wed., 23 April.

Illuminating Engineering Society

BATH
Annual General Meeting. Bath and Bristol Centre. Offices of the South Western Electricity Board, Bath. Mon., 21 April, 7 p.m.

BIRMINGHAM
Discussion on "Light and Colour." Birmingham Centre. Regent House, St. Phillip's Place, Colmore Row, Birmingham. Fri., 25 April, 6 p.m.

LEICESTER
Annual General Meeting. Leicester Centre. Bell Hotel, Leicester. Mon., 21 April, 7 p.m.

Incorporated Plant Engineers

BIRMINGHAM
Film: "Hydraulic Power at Rawden Colliery." Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 25 April, 7.30 p.m.

CARDIFF
"Effects of Steam Peaks," by Dr. E. G. Ritchie. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 22 April, 7.15 p.m.

COVENTRY
Film "Taking the Load." Birmingham Branch. Hotel Leofric, Coventry. Tues., 22 April, 7.30 p.m.

LEEDS
"The Raising of the Hoenfells," by A. T. Bride. West and East Yorkshire Branch. The University, Leeds. Mon., 28 April, 7.30 p.m.

SHEFFIELD
"Factory Services and Supplies, with Particular Reference to Gas Requirements and Installation," by F. Dickinson. Sheffield Branch. Grand Hotel, Sheffield. Thurs., 24 April, 7.30 p.m.

Institute of Fuel

LONDON
Presidential Address by H. McNeil. Institution of Civil Engineers, Great George Street, S.W.1. Wed., 23 April, 6.30 p.m.*

Institute of Marine Engineers

LONDON
Annual General Meeting. Tues., 22 April, 5.30 p.m.*
Discussion on "Marine Machinery Breakdowns," opened by J. H. Milton. Thurs., 24 April, 5.30 p.m.*

Institute of Physics

ABERYSTWYTH
"Rock Magnetism and the Wandering of Continents," by Professor P. M. S. Blackett. South Wales Branch. University College of Wales, Aberystwyth. Fri., 25 April, 8 p.m.

MALVERN
One-day symposium: "Some Applications of Solid State Physics in Computers and Automation." Midland Branch and Electronics Group. Priory Lodge Hall, Winter Gardens, Malvern. Tues., 29 April, 10.30 a.m.

Institute of Refrigeration

LONDON
"Current Practice in Marine Insulation," by G. Laing. Junior Institution of Engineers, Pepys House, Rochester Row, S.W.1. Thurs., 1 May, 5.30 p.m.*

Institute of Road Transport Engineers

DURHAM
Annual General Meeting. North Eastern Centre. Three Tuns Hotel, Durham City. Tues., 22 April, 7 p.m.

GLASGOW
Annual General Meeting. Scottish Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Mon., 21 April, 7.30 p.m.

HOVE
Annual General Meeting. Southern Centre. 71 Cromwell Road, Hove. Fri., 25 April, 7.30 p.m.

Institution of Chemical Engineers

MANCHESTER
Discussion on "Modern Processes in Petroleum Refining." North Western Branch. College of Science and Technology, Manchester. Thurs., 24 April, 7 p.m.

Institution of Civil Engineers

LONDON
"Hydrology and Water Development in Cyprus," by I. L. Ward, D. P. McGregor and M. Grehan. Tues., 22 April, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "A Review of Industrial Ultrasonics." London Graduate and Student Section. Tues., 22 April, 6.30 p.m.*
"Survey of Performance Criteria and Design Considerations in High-Quality Monitoring Loud Speakers," by D. E. L. Shorter. Radio and Telecommunication Section. Wed., 23 April, 5.30 p.m.*
"The Generation of Electricity in the London Area," by H. V. Pugh. Thurs., 24 April, 5.30 p.m.*
"Economic Usage of Broad-Band Transmission Systems," by R. J. Halsey. Radio and Telecommunication Section. Mon., 28 April, 5.30 p.m.*

EDINBURGH
Annual General Meeting. South East Scotland Sub-centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 29 April, 7 p.m.

GLASGOW
"Operational Experience: Calder Hall," by K. L. Stretch. South West Scotland Sub-centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Tues., 22 April, 7 p.m.

MANCHESTER
Annual General Meeting. "Supply-Voltage and Current Variations Produced by a 60 ton Three-Phase Electric-Arc Furnace," by Dr. B. C. Robinson and A. I. Winder. North Western Centre. Engineers' Club, Albert Square, Manchester 2. Tues., 6 May, 6.15 p.m.

Institution of Engineering Designers

LONDON
"Some Aspects of Weight Control in Design," by J. McLaughlin and F. Howarth. Thurs., 24 April, 6.45 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
Annual General Meeting. "Heating and Hot-Water Supply and Demand in Flats," by K. W. Dale. Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C.2. Tues., 29 April, 7 p.m.

Institution of Locomotive Engineers

LONDON
Films: "Introducing Work Study," "Forgemasters in Steel," and "High-Speed Flight—Part I, Approaching the Speed of Sound." Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Thurs., 1 May, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "Availability of Power Plant." Steam Group. Tues., 22 April, 6 p.m.*
Discussion on "Teaching the Fundamentals of Automatic Control." Education Group. Wed., 23 April, 6 p.m.*
"First Year of Operation of a Cyclone-Fired Boiler," by R. P. McCulloch, J. R. Willetts and A. Richardson. Meeting in conjunction with the Steam Group. Fri., 25 April, 6 p.m.*
Discussion on "How Small Can a Motor Car Be?" Automobile Division. Tues., 29 April, 6 p.m.*
"Some Methods of Manufacture and Applications of Flexible Metallic Tubing," by C. Bateman. London Graduates' Section. Thurs., 24 April, 6.30 p.m.*

BRISTOL
"Inspection of Vehicles for Road Worthiness, with Special Reference to Methods and Equipments," by G. Grime and R. D. Lister. Western A.D. Centre. Royal Hotel, Bristol. Thurs., 24 April, 6.45 p.m.

SWANSEA
"Management Control of Small Engineering Firms," by L. Fontaine, W. R. Spencer and J. W. Walker. South Wales Branch. Offices of the South Wales Electricity Board, The Kingsway, Swansea. Tues., 22 April, 6 p.m.

Institution of Production Engineers

LONDON
"The Engineering Industry Since the War," by Professor M. Postan. South Eastern Region. Royal Empire Society, Northumberland Avenue, Strand, W.C.2. Thurs., 24 April, 7 p.m.
Various short lecturettes. London Graduate Section. Wed., 30 April, 7.15 p.m.

COVENTRY
Annual General Meeting. Illustrated lecture: "Karakoram Himalayan Expedition, 1957," by J. Miller. Coventry Graduate Section. Coventry Arms Hotel, High Street, Coventry. Mon., 21 April, 7.15 p.m.

MANCHESTER
"Human Problems in Industry," by the Rt. Rev. Bishop of Manchester. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., 28 April, 6.30 p.m.

Institution of the Rubber Industry

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles Street, Birmingham. Wed., 30 April, 6.45 p.m.

GLASGOW
Annual General Meeting. "Rubber in Engineering," with film, by P. B. Lindley. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Tues., 29 April, 7.30 p.m.

Junior Institution of Engineers

MANCHESTER
Repetition of Presidential Address "The Origin and Function of R.E.M.E.," by Major General W. A. Lord. North Western Section. Engineers' Club, Albert Square, Manchester. Tues., 29 April, 7.30 p.m.

Leeds Metallurgical Society

LEEDS
Annual General Meeting. "Chromising," by Dr. M. L. Becker. Chemistry Wing, The University, Leeds, 2. Thurs., 1 May, 7.15 p.m.

Modular Society

LONDON
Open Meeting. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Thurs., 24 April, 7.30 p.m.

North East Metallurgical Society

MIDDLESBROUGH
Annual General Meeting. Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough. Tues., 29 April, 7.15 p.m.

Reinforced Concrete Association

LONDON
"Recent Developments in Prestressed Concrete in Belgium," by Professor D. Vandepitte. Institution of Structural Engineers, 11 Upper Belgrave Street, S.W.1. Wed., 23 April, 6 p.m.*

Royal Meteorological Society

LONDON
Annual General Meeting. Presidential Address on "Transfer Across the Earth's Surface and Through the Air Above," by Professor P. A. Sheppard. Wed., 23 April, 5 p.m.*

Royal Society

LONDON
"Seismic Measurements Made by H.M.S. Challenger in the Atlantic, Pacific and Indian Oceans and in the Mediterranean Sea, 1950-53," by T. F. Gaskell, M. N. Hill and J. C. Swallow; and "Geological Interpretation of Gravity and Magnetic Surveys in Devon and Cornwall," by M. H. P. Bott, A. A. Day and D. Masson-Smith. Thurs., 1 May, 4.30 p.m.*

Royal Society of Arts

LONDON
"Prestressed Concrete," by G. W. Kirkland. Lecture II. Mon., 21 April, 6 p.m.
"Overseas Surveys," by Brigadier Martin Hotine. Tues., 22 April, 5.15 p.m.*

Society of Instrument Technology

LONDON
"Data Loggers," by J. L. W. Churchill; "Experience Gained in Using Logging Equipment," by D. H. Whiting; and "Experience Gained in Using Scanning Equipment," by J. Dunkley. Manson House, Portland Place, W.1. Tues., 29 April, 7 p.m.*

CHESTER
Annual General Meeting and Film Evening. Chester Section. 5 King's Buildings, King Street, Chester. Wed., 30 April, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"Modernisation of the Western Region of British Railways," by M. G. R. Smith and R. A. Smeddle. Thurs., 24 April, 6 p.m.

Town and Country Planning Association

LONDON
"Public Planning and Private Enterprise," by J. F. Q. Switzer. Thurs., 24 April, 6.15 p.m.

Women's Engineering Society

LONDON
"Philosophy of Guided Missile Design," by Wing-Commander P. M. Chettle. London Branch. Electricity Council's Offices, Winsley Street, W.1. Mon., 21 April, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Physics, 47 Belgrave Square, London, S.W.1. (BELgravia 6111.)
Institute of Refrigeration, New Bridge Street House, New Bridge Street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria Street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Modular Society, 22 Buckingham Street, London, W.C.2. (TRAfalgar 4567.)
North East Metallurgical Society. Apply to Mr. A. H. Burn, 35 Central Avenue, Billingham, Co. Durham.
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Meteorological Society, 49 Cromwell Road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Society of Instrument Technology, 20 Queen Anne Street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park Place, Cardiff. (Cardiff 23296.)
Town and Country Planning Association, 28 King Street, London, W.C.2. (TEMple Bar 5006.)
Women's Engineering Society, 25 Foubert's Place, London, W.1. (GERrard 5212.)

Engineering at Home

RECORDING TELEVISION PICTURES MAGNETICALLY

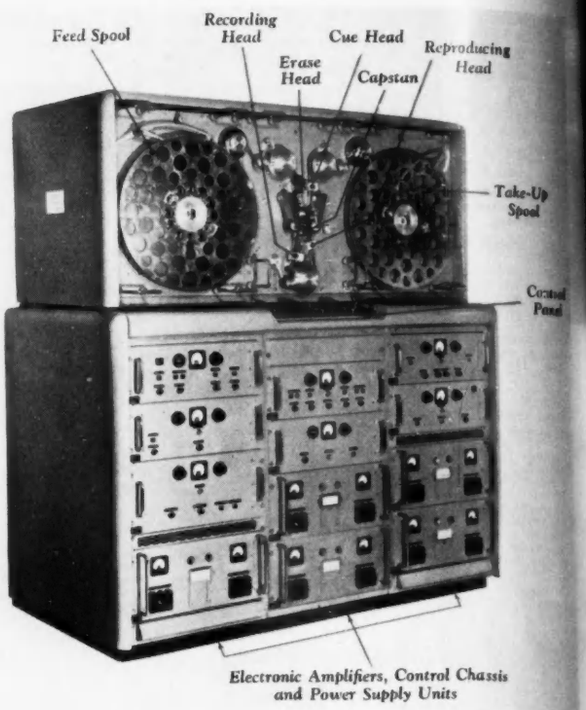
The B.B.C. have developed equipment for recording television pictures on magnetic tape. Until recently, the only way of recording television programmes for later reproduction was to use photographic film. Such a system was not completely satisfactory. The film had to be processed, which meant some delay, and in many cases there was an appreciable loss in quality. In addition the film was expensive, and could only be used once.

Magnetic tape can be used again and again. Signals on it can be wiped off or retained as desired. However, although tape has been used for some time to record sound programmes, its use as a medium for storing pictures has presented considerable difficulty. In sound recording, the magnetic tape recorder accepts electrical impulses from a microphone, say, and converts them into a pattern of miniature magnets along the length of the tape. The higher the frequency of the sound, the closer together are the electrical impulses; naturally, this means that the corresponding magnetic pattern is crowded closer together too. Unfortunately, there is a limit to the closeness that the magnets can be packed. To get high frequencies on to a tape, therefore, it has to be run faster. It is because of this that most tape recorders have two tape speeds: slow, for making long recordings of speech, say, when the absence of the top notes is not noticed much; and fast, for making shorter recordings of higher quality—pieces of music, for example.

Television systems contain much higher frequencies than are found in sound recording. The electrical impulses coming from a television camera have a band of frequencies some 300 times as wide as that required for high quality sound. So to record pictures on tape it is necessary to run the tape at a very much higher speed. This has been the main problem in developing the new equipment, achieving the high tape speed and maintaining it accurately at a given value—fluctuations in speed cannot be tolerated, they introduce distortion. The reproducing heads, too, have to be designed to handle the higher frequencies.

The B.B.C. system uses a standard grade of magnetic tape that is in general commercial use for sound recording. It is half an inch wide. Three tracks are impressed on the tape. The lower part of the television frequency band is recorded on one magnetic track, using frequency modulation, and the higher frequencies are recorded on a second. The accompanying sound is recorded on the third track. A tape speed of 200 in per sec is employed.

The B.B.C. research department has been working on the equipment since 1956. It will shortly be put into experimental service at Lime Grove, where it is expected that the machine will fulfil the need for a means of recording television transmissions economically, giving pictures of good quality available for immediate playback. The full name of the equipment is " vision electronic recording apparatus," which is, of course, expressed as an affectionate contraction—Vera.



The equipment for recording television signals on magnetic tape is expected to be economical and to make good quality pictures available for immediate playback. The chief feature is the high tape speed.

HOUSING IN TIMBER

Ten houses, each of them claimed to be a solution to a typical client's problem, have been designed by a panel of British architects appointed by the British Columbia Lumber Manufacturers Association. The house plans, supplemented by information about the system of Canadian timber frame construction which they exemplify, are included in an informative 18-page booklet published by the British Columbia Lumber Manufacturers Association. The designs illustrated in the new booklet indicate broadly what can be achieved, but the publishers emphasise that individual requirements can be met most satisfactorily by commissioning an architect for each job.

House designs have been prepared to suit a cross-section of the public. In the lower price brackets (£1,750 to £2,280) there are terraced agricultural cottages, which will interest farmers, landowners and local councils, and small bungalows for retired couples. Then there is a choice of designs, costing between £2,500 and £3,000, for the estate developer. Other designs include a four-bedroom house for a rural solicitor, a modern split-level house for an advertising agent with four children, and a more spacious house costing around £5,000 for a professional man requiring working facilities away from the office.

The basic system followed by most of the panel architects is platform frame construction executed in fully surfaced Pacific Coast hemlock. Constructional variants include post and beam technique, as well as use of laminated-timber roof members and plywood box beams. All houses illustrated in the booklet conform to a higher standard of insulation than conventional houses with brick cavity walls. Almost in every case the houses designed by the panel are equipped with one or other form of central heating—hot water radiators, ducted warm air, or under-floor electricity. All houses are of " dry construction " throughout and are proof against condensation.

Panel architects have had a free hand in choosing cladding materials for the exterior facing of the structural hemlock frames. Western red cedar has been specified in a number of instances for whole-wall or partial treatments; other finishes include brick, stone, rendering and shingles used in combination with untreated, stained and painted timber.

Copies of the illustrated booklet " Housing Trends " may be obtained free of charge on application to the Commercial Counsellor (Timber), Canada House, London, S.W.1.

OUTDOOR LIGHTING

A number of weatherproof fittings for outdoor lighting are produced by Philips Electrical Limited, Shaftesbury Avenue, London. One is a fitting for 150 watt pressed-glass reflector lamps. It is adjustable through 180° in the vertical plane and 360° in the horizontal plane. A silicone heat-resisting rubber gasket seals the fitting against moisture. Four versions are available: on a free-standing base connected by a watertight cable gland; attached to a spike that can be pushed into soft ground; with a conduit adaptor for mounting on ¾ in conduit; or with a baseplate in addition to spike mounting.

Watertight fluorescent fittings are available in single and twin lamp versions for 4 ft 40 watt and 5 ft 80 watt switch-start lamps. The fittings can be suspended or fixed directly to a wall. A body of rigid ivory P.V.C. is used, and the lampholders are seated on synthetic rubber gaskets and clamped to the outside. The heavy-gauge metal control-gear trays run the length of the fittings, and gaskets set in the end caps seal the body against moisture. The mild steel suspension brackets are galvanised, and the brass connecting screws are nickel plated.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

CHAIRMAN: J. A. Dixon, M.A., A.M.I.Mech.E.
EDITOR: F. B. Roberts, M.B.E., A.M.I.Mech.E., A.M.I.Loco.E.
DEPUTY EDITORS: D. Fisher, Ph.D., B.Sc., A.M.I.C.E., A.M.I.Mech.E.; E. P. Ward, M.A., A.M.I.Mech.E.
ASSISTANT EDITORS: E. I. Brimelow, M.Eng., Assoc.I.Mech.E., A.I.M.; J. E. Dodsworth; W. K. V. Gale, M.I.S.I.; J. T. Godfrey; R. Lemmy, A.I.M., M.I.S.I.; M. Neal, B.Sc., D.I.C., A.F.R.Ae.S.; R. G. Pay, M.Sc.; A. A. H. Scott, B.Sc., A.M.I.Mech.E.
SUBSCRIPTION MANAGER: G. A. Roberts.
ADVERTISEMENT MANAGER: G. H. Dixon.

Annual subscription rates: Inland and abroad £5 10*s*. (Canada, £5 5*s*.). Three months, 27*s*. 6*d*. all countries. **Single copies,** 2*s*. 7*d*. post free.

Engineering Information Service: Assistance is available from Engineering Information Service in obtaining information, and in locating sources of information, both technical and commercial. E.I.S. deals with, for example, names of makers and suppliers of plant and equipment, technical data on design, markets for engineering products, and compilation of references to information on specific topics. Inquiries should be addressed to Engineering Information Service at the address given in the left-hand column.